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EDMONTON COAL RESEARCH LABORATORY

KILBORN PROJECT NO. 7813-15

# DEVELOPMENT AND DESIGN OF A PILOT PLANT FOR DEEP COAL CLEANING

## PHASE I

## REPORT ON

## INFORMATION COLLECTION STAGE

223 pp

SUBMITTED BY:

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February 3, 1986

Edmonton Coal Research Laboratory
CANMET
One Oil Patch Drive
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Attention: Mr. M. W. Mikhail
Project Scientific Authority

Dear Sirs:

Please find enclosed fifteen (15) copies of the report covering the 'Information Collection Stage' which is submitted to you as the conclusion of Phase I of the current project "Development and Design of a Pilot Plant for Deep Coal Cleaning".

We hope that this report meets with your satisfaction and if further more specific information is required either immediately following your receipt of this report or later as the project proceeds, please note that we will be maintaining a 'hard-copy' file of useful technical information including references, which is available to you as required.

Yours very truly,

KILBORN ENGINEERING (B.C.) LTD.

R Davies

R. J. Davies
Project Manager

RJD/rlk
Enclosures

EMR : CANMET

EDMONTON COAL RESEARCH LABORATORY

KILBORN PROJECT NO. 7813-15

# DEVELOPMENT AND DESIGN OF A PILOT PLANT FOR DEEP COAL CLEANING

## PHASE I

## REPORT ON

## INFORMATION COLLECTION STAGE

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# 1.0 INTRODUCTION

# 1.0 INTRODUCTION

Canada Energy, Mines and Resources (EMR) has requested the design of a coal deep cleaning pilot plant that will expand their existing, 10 tonnes per hour, pilot plant facilities at the Edmonton Coal Research Laboratory (CRL), Devon, Alberta.

The pilot plant will be designed for the following capabilities:

(a) Wet grind coal to produce a coal-water slurry.

(b) Wet grind coal and 'deep clean' the pulverized product to a low ash level to produce a high grade coal-water slurry.

(c) Be able to test promising 'deep cleaning' technology on a variety of Canadian coals.

Phase I of this Project is the Information Collection Stage.

The objectives of Phase I are:

(a) Identify processes that have been developed for the 'deep cleaning' of natural arising or pulverized fine coal, and carry out a literature survey.

(b) Review the suitability of these processes for installation at CRL and the select relevant ones.

(c) Identify and gather information on pilot plants using 'deep cleaning' processes.

(d) Establish the most effective method of grinding coal for this pilot plant.

## 2.0 SUMMARY

## 2.0 SUMMARY

A general description of each identified process has been given, followed by a listing of the major variations developed. An effort has been made to try and assess how far the process is established and if it would be viable at the pilot plant level required. Pilot plant details of the processes have been recorded to try and include as many good process design features as possible into the design of the Deep Coal Cleaning Pilot Plant for CANMET. No attempt has been made to describe the test results achieved with individual processes.

The pilot plant survey was conducted by letter, telephone, and from technical descriptions in the literature. The survey has been largely confined to North America and the English-speaking world. It became clear from the survey that no pilot plant exists with several options for the 'deep cleaning' of fine coal, although there are some plans to do this, namely EPRI, Ames, and the Swedish State Power Board.

The coal milling technical survey indicated that the vast majority of facilities that grind coal for 'deep cleaning', or for the production of coal-water mix, use wet ball mills. Many, however, are relatively unsophisticated in that they have limited control of the size consist of the product. Several of the pilot plants control the size by the use of classifying cyclones and/or fine-sizing screens.

The conclusions of the Study are summarized as follows:

(1) Coal grinding will be carried out by wet ball milling, and the product size consist controlled by the use of classifying cyclones.

(2) The 'deep cleaning' processes selected for inclusion in the pilot plant are:

(a) Two-stage froth flotation (including reverse flotation).
(b) Spherical oil agglomeration.
(c) High grade magnetic separation (with facilities for magnetic enhancement of the feed).
(d) Small-scale electrostatic separation (off-line).

# 3.0 DEEP CLEANING OF COAL: LITERATURE SURVEY

# 3.0 DEEP CLEANING OF COAL: LITERATURE SURVEY

## 3.1 FROTH FLOTATION

A considerable amount of work has been done on froth flotation studies at the pilot plant scale at many test facilities throughout the world. Pilot plant equipment is well documented and well known. It is not within the scope of this survey to review froth flotation research currently being carried out. However, aspects of froth flotation research that could have an effect on layout and design have been carefully examined.

### 3.1.1 Reagent Storage

The bulk of froth flotation research has been carried out on reagents to improve flotation properties. Facilities in the pilot plant should include reagent storage and feeding for:

(a) Frothers
(b) Collectors
(c) Promotors
(d) Depressants
(e) Modifiers.

### 3.1.2 Reagent Addition

An effective dispersion (emulsification) system for water-insoluble oily collectors should be installed. Such dispersion can be accomplished in suspension by the use of emulsifiers, or by gas phase transportation. Dispersion of the water-insoluble hydrocarbon oil is a critical issue in the achievement of improved flotation efficiency.

Gas-phase transportation of reagents should be considered.

The technique involves atomization of oily reagents into the gas (air) stream. An aerosol can be introduced into the flotation cell so that, initially, the oil is dispersed within the gas phase and the gas is dispersed within the slurry.

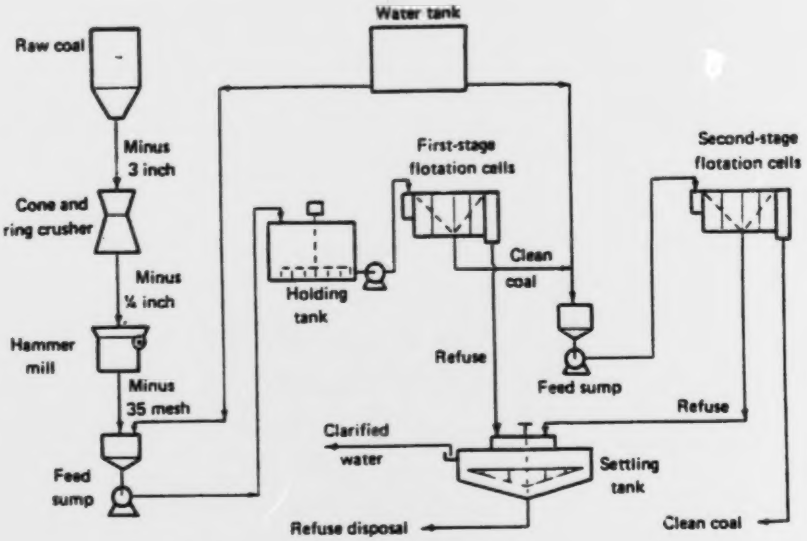
Arrangements must be made for the stage addition of reagents to the individual cells.

### 3.1.3 Two-Stage Flotation/Reverse Flotation

Rougher and cleaner stages should be installed to study stage flotation, and facilities should be included for reverse flotation tests. Two-stage reverse flotation of pyrite from coal has been developed as a possible process strategy for improved desulphurization of fine coal. In essence, the first stage of the reverse flotation process is conventional flotation, which takes advantage of the coal particles' natural hydrophobicity, and during which coal is floated away from hydrophilic gangue (shale, clay and some pyrite). The second stage involves flotation of pyrite particles remaining in the first-stage clean coal product with use of a sulphydryl collector such as xanthate, and an organic colloid depressant such as dextrin. (Coal depression occurs at dextrin concentrations of 1.0 milligrams per litre corresponding to less than 10 percent surface coverage, whereas pyrite with xanthate as a collector is only modestly affected at 100 gallons per litre. There is, therefore, a large window for selectivity between the two components.)

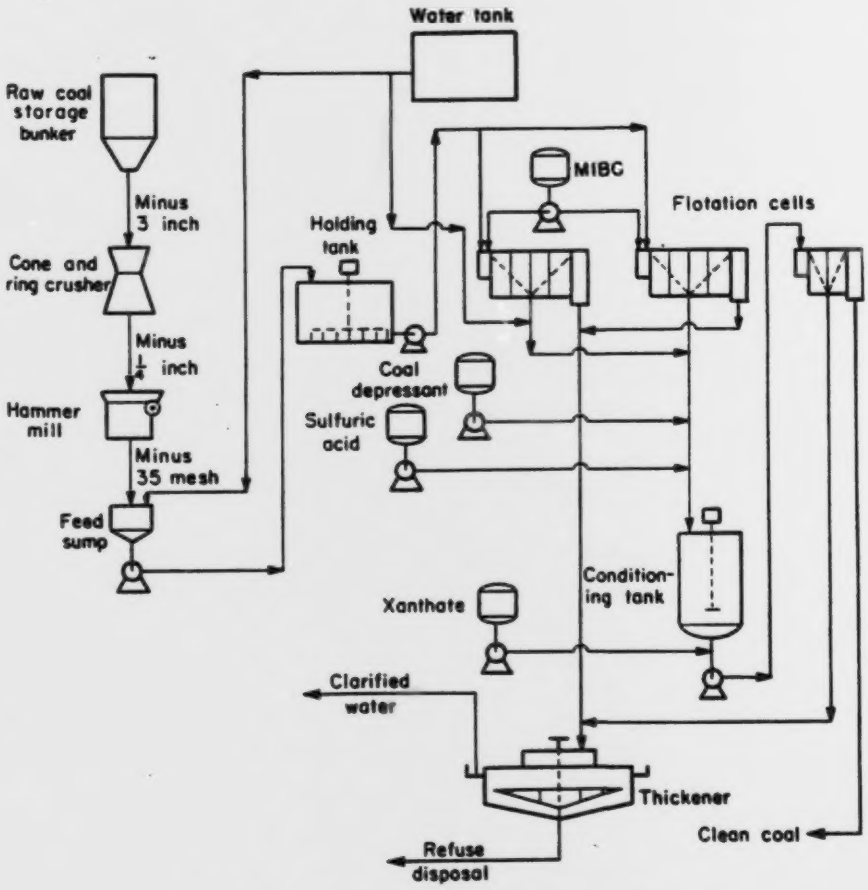
A two-stage reverse flotation pilot plant was installed at the Department of Energy (DOE) (Figure 3.1.3-1). A raw run-of-mine coal sample was fed from a 25-ton capacity coal storage bunker through a cone-and-ring crusher and a hammer mill to produce a minus 35 mesh feed material. The fine coal was mixed with water in a feed sump at a controlled rate to produce a slurry of about 8.0 percent (weight) solids. The slurry was pumped to a 1,000 gallon capacity slurry holding tank from which it was fed to the flotation cells. The slurry depth in the holding tank was automatically controlled by high and low level probes. MIBC was added to the feed box of the first-stage flotation machine. For second-stage flotation, the first-stage froth concentrate was diluted with makeup water to its original volume, and the coal depressant (Aero 633) was added along with an acid to reduce pH to a slightly acidic level. The slurry was then pumped from the feed sump to the second-stage flotation cells where the pyrite collector (potassium amyl xanthate) and additional MIBC were added. Both first- and second-stage flotation machines in the pilot plant were composed of four 0.6 cubic feet capacity, WEMCO Fagergren flotation cells.

Although excellent pyrite removal was achieved using the above technique, the final clean coal product was recovered as a rather dilute underflow containing 6-8 percent (weight) solids. This presented some formidable dewatering problems. It was also found that only one-half to one-quarter as much slurry retention time was needed in the second stage. In an effort to minimize the clean coal dewatering problem and to make more efficient use of the flotation cells, the two-stage pilot plant was modified as shown in Figure 3.1.3-2). The first-stage coal flotation was carried out in two parallel banks, each containing four cells. The froth concentrate was then diluted as before except that the xanthate was added ahead of the second-stage feed pump to provide extra conditioning time. Also, no MIBC was needed in the second-stage because of the residual in


Water tank
Raw coal
Minus 3 inch
Cone and ring crusher
Minus ¼ inch
Hammer mill
Minus 35 mesh
Feed sump
First-stage flotation cells
Second-stage flotation cells
Holding tank
Clean coal
Refuse
Feed sump
Refuse
Clarified water
Settling tank
Refuse disposal
Clean coal

Two-stage flotation pilot plant flow diagram.

FIGURE 3.1.3-1


Water tank
Raw coal storage bunker
Minus 3 inch
Cone and ring crusher
Minus ¼ inch
Hammer mill
Minus 35 mesh
Feed sump
Holding tank
MIBC
Flotation cells
Coal depressant
Sulfuric acid
Conditioning tank
Xanthate
Clarified water
Thickener
Clean coal
Refuse disposal

Modified two-stage flotation pilot-plant flow diagram.

FIGURE 3.1.3-2

the more concentrated pulp. Results with the modified circuit were similar to those obtained in earlier laboratory and pilot plant tests, but the final clean coal slurry was in a more concentrated form (12-13 percent).

### 3.1.4 Size Classification Before Froth Flotation

If research is planned on the froth flotation of selective size fractions, then consideration should be given to installing fine coal screens or classifying cyclones ahead of the froth flotation section, or incorporating the classifying cyclones in the ball mill circuit for this purpose. This has been considered for introduction in certain commercial plants in the Rocky Mountain operations where distinctly different flotation characteristics have commonly been encountered for 0.6 by 0.5 millimetre and 0.15 millimetre by zero size fractions.

Figure 3.1.4-1 shows a simplified flowsheet for a coarse and fine parallel flotation circuit.

## 3.2 GRAVITY SEPARATION

Traditionally, gravity separation has not been used extensively for fine coal cleaning of minus 0.5 millimetre fines, due to the fact that they are separated relatively inefficiently. Froth flotation has generally been used where the coal is amenable, and gravity separation has usually been a second choice.

The methods used for fine coal cleaning by gravity, are water-only cyclones and concentrating tables and spirals. All three are relatively inefficient processes. Recently, heavy media processes have been used for washing coal to zero, i.e., including the minus 0.5 millimetre in the feed, but this has so far not been attempted in Canada.

## FIGURE 3.1.4-1

## COARSE AND FINE FLOTATION CIRCUIT

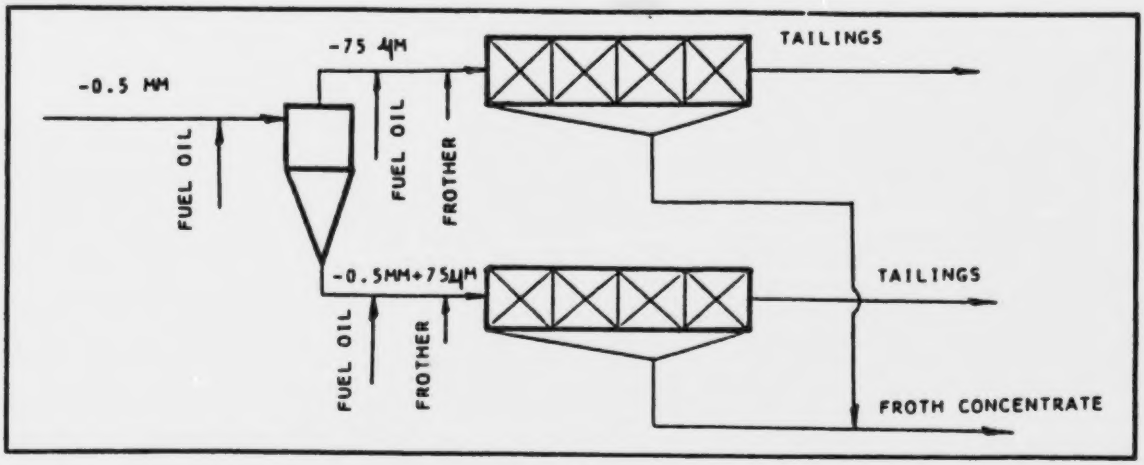

-0.5 MM
-75 μM
TAILINGS
FUEL OIL
FUEL OIL
FROTHER
-0.5MM+75μM
TAILINGS
FUEL OIL
FROTHER
FROTH CONCENTRATE

Fig. 3 — Classified coarse and slime flotation circuit.

Few pilot plants are carrying out research in this area, although EPRI has been doing work on water-cyclone cleaning of fine coal, and DOE Pittsburgh plans to carry out fine coal cleaning in cyclones using heavy liquids.

The People's Republic of China is developing a centrifugal concentrating table which could be used for fines cleaning.

Perhaps the most promising potential gravity fines cleaning device is the new generation of coal spirals, which may be able to effectively clean pulverized coal down to a size of perhaps 25-30 microns, especially in desulphurization applications. Below this size, gravity concentration becomes ineffective by any method.

## 3.3 OIL AGGLOMERATION

### 3.3.1 NRCC Pilot Plant

Pelletization, the selective spherical agglomeration of suspended solids, is based on the difference in wettability of solids by different liquids. If a small amount of liquid which wets the solids better than the suspending liquid is added to a suspension, then flocculation occurs. On agitation, the floccules turn into dense agglomerates. These can be further compacted and rendered spherical in suitable pelletization equipment. If some of the solids (e.g., shale) by their nature are not wetted by the agglomeration liquid, they will remain suspended in the original carrier liquid. Heavy fuel oil is usually employed as the agglomerating liquid when pelletizing, whereas light-medium fuel oil is best employed in the ash reduction step. Coal pellets can be dewatered easily on screens while the non-coal matter remains suspended in the watery phase.

The sequence of operations in oil agglomeration usually includes:

(a) Selective flocculation (or microagglomeration).
(b) Agglomerate recovery with simultaneous impurity rejection.
(c) Size enlargement (pelletization) of the recovered and beneficial coal particles with simultaneous further rejection of tailings and moisture.
(d) Thermal treatment of the product to remove moisture and/or harden binders.

A generalized flow diagram of the NRCC spherical oil agglomeration process is shown in Figure 3.3.1-1.

Some important features of the process are:

(a) To achieve initial oil dispersion and efficient wetting of the carbonaceous surfaces, some form of high-intensity mixing or prolonged contact is required. Addition of the oil in water, prior to mixing with the coal slurry or during an upstream size-reduction operation, has been used to improve this initial oil-coal contacting.

(b) In some cases, the small agglomerate produced in the first stage may be adequate for many applications, e.g., slurry pipelining.

(c) Where larger pellets are required for conventional storage and shipment of the coal product, the heavy binding oils used to form such larger agglomerates are generally poorly suited to good initial ash rejection. The two-stage process then allows the initial selective agglomeration and ash rejection to be accomplished with lighter oils to maximize impurity removal.

## FIGURE 3.3.-1

## NRCC SPHERICAL AGGLOMERATION PROCESS FLOWSHEET

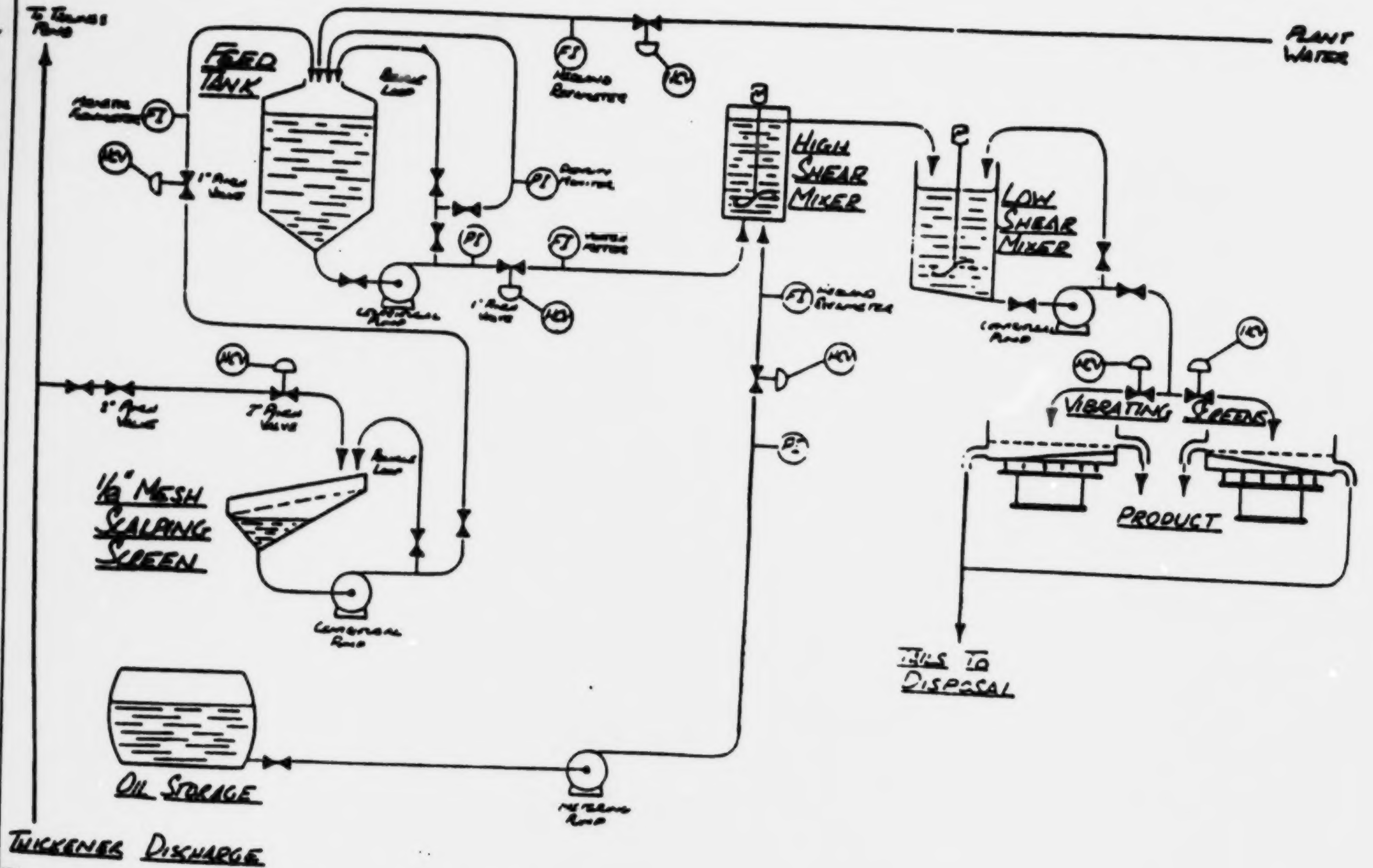

To Tailings Pump
FEED TANK
Bypass Loop
FS
HCV
1" Pinch Valve
PI
Density Monitor
FT
Water Meter
Centrifugal Pump
PLANT WATER
HIGH SHEAR MIXER
LOW SHEAR MIXER
VIBRATING SCREENS
PRODUCT
TAILS TO DISPOSAL
3" Pinch Valve
1/8" MESH SCALPING SCREEN
Centrifugal Pump
OIL STORAGE
Metering Pump
THICKENER DISCHARGE

Figure 5 Process flowsheet for NRCC mobile pilot plant.

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(d) Oil agglomeration displaces moisture effectively from even the finest coal particles. If agglomerates larger than about 2 millimetres are produced, thermal moisture removal is not required to obtain a product with less than about 10 percent moisture (weight), although some thermal treatment may be necessary to harden binders.

The history of oil agglomeration goes back to the early part of the century to the Trent process. Since that time, much work on oil agglomeration, especially spherical agglomeration, has been carried out in all the major coal-producing countries.

### 3.3.2 Ontario Hydro Pilot Plant

A 1/4-ton per hour pilot plant (Figure 3.3.2-1) was established at Ontario Hydro Research Division, Toronto. The four sections of the plant are coal grinding, coal and oil feeding, coal agglomeration and product separation/dewatering. The coal is ground in the ball mill (wet), with a 30-minute rentention time to produce a high density slurry which is then kept in storage tanks. The slurry can be adjusted to the appropriate concentration and the coal slurry and oil feed simultaneously to the agglomeration system. After agglomeration, the slurry flows by gravity to a rotary sieve. The overflow from the rotary sieve is the agglomerated coal product while the rejects and most of the water are in the underflow.

Typical ball mill product obtained is 60 percent minus 74 micron, but some coal has been reground to 96 percent minus 74 micron. It was found that a western Canadian coal tested, was difficult to agglomerate. It was necessary to connect the two high shear mixers in series, and also use a 200 litre tank with a stirrer and a recirculation system to provide additional mixing (Figure 3.3.2-2) in order to properly agglomerate this coal.

FIGURE 3.3.2-1

SCHEMATIC DIAGRAM OF THE EQUIPMENT
USED BY ONTARIO HYDRO

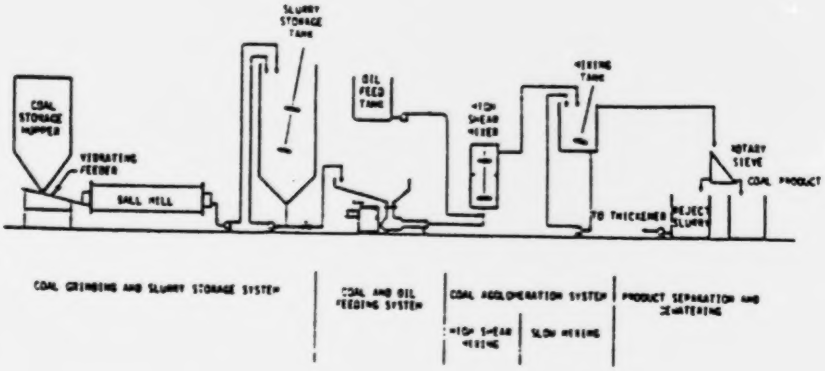
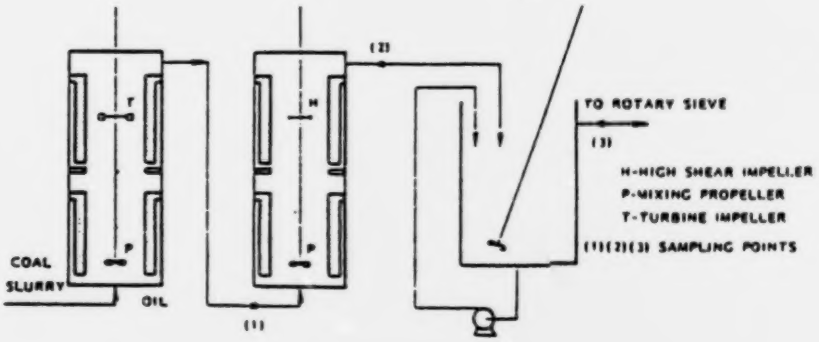

SLURRY STORAGE TANK
OIL FEED TANK
MIXING TANK
COAL STORAGE HOPPER
HIGH SHEAR MIXER
ROTARY SIEVE
VIBRATING FEEDER
COAL PRODUCT
BALL MILL
TO THICKENER
REJECT SLURRY
COAL GRINDING AND SLURRY STORAGE SYSTEM
COAL AND OIL FEEDING SYSTEM
COAL AGGLOMERATION SYSTEM
HIGH SHEAR MIXING
SLOW MIXING
PRODUCT SEPARATION AND DEWATERING

FIGURE 3.3.2-2

SCHEMATIC DIAGRAM OF THE AGGLOMERATION SYSTEM


(2)
T
H
TO ROTARY SIEVE
(3)
H-HIGH SHEAR IMPELLER
P-MIXING PROPELLER
T-TURBINE IMPELLER
P
P
(1)(2)(3) SAMPLING POINTS
COAL
SLURRY
OIL
(1)

### 3.3.3 Iodna Pilot Plant (India)

The 2-tonne per hour pilot plant (Figure 3.3.3-1) treats coals ground to 100 micron. Slurry at 30-35 percent solids is fed to a conditioner where it is treated with 1-2 percent light diesel oil while maintaining a slightly alkaline pH. In the case of middlings or high ash coals, the feed to the ball mill is ground to 80 percent minus 100 micron, in the presence of 1-2 percent light diesel oil. Low ash slurry can also be fed to the ball mill for conditioning. Conditioned pulp from the conditioners is diluted to 15-20 percent solids before being fed to horizontal agglomeration cells, where the pulp is subjected to high speed agitation while adding heavier oils such as furnace or creosote oil (10-18 percent weight). During the agitation with oil, separation of coal and shale particles takes place with the simultaneous formation of spherical pellets of demineralized coal. The pellets are then dewatered initially on a sieve bend and finally on a horizontal vibrating screen. The underflow from the sieve bend and screen containing the high ash tailings flow to a settling pond.

### 3.3.4 BHP Pilot Plant (Australia)

A 0.3-tonne per hour pilot plant was originally constructed, following much bench-scale work for treating underflow slurry from a jig plant. The material was 66 percent minus 53 micron with an ash content of 35-40 percent. The slurry was from the receiving tank to the reactor. Pre-emulsified oil was added to the tank. The agglomerated coal product and underflow tailings were discharged as an overflow from the tank into the sieve bend with water sprays to improve demineralization of the agglomerated product. The clean coal product is discharged from the screen onto the product belt while the tailings pass through the screen to the settling ponds. More recently, a 30-tonne per hour test unit has been built incorporating a 1.6

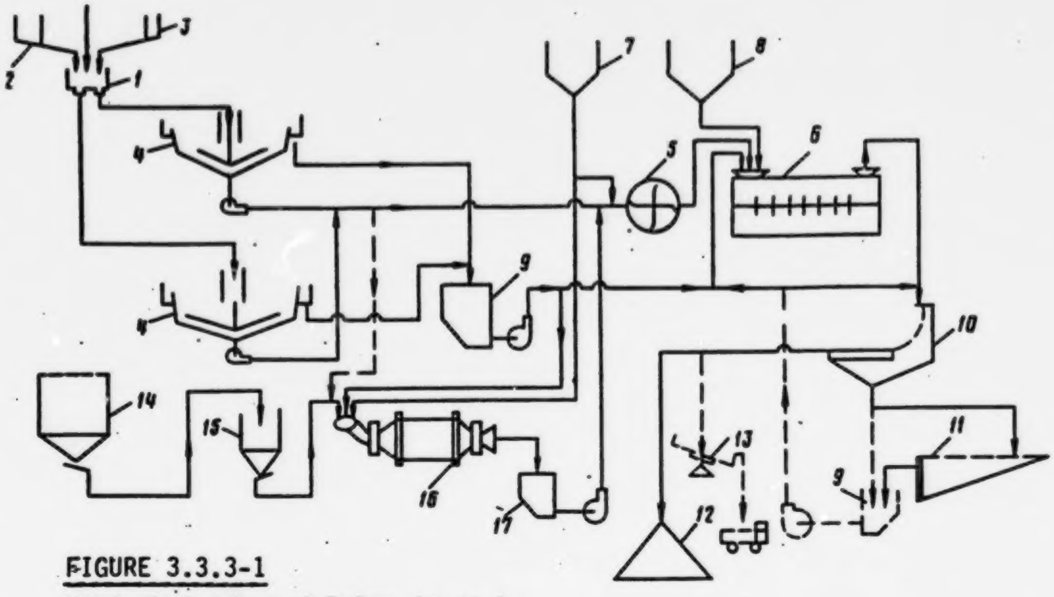
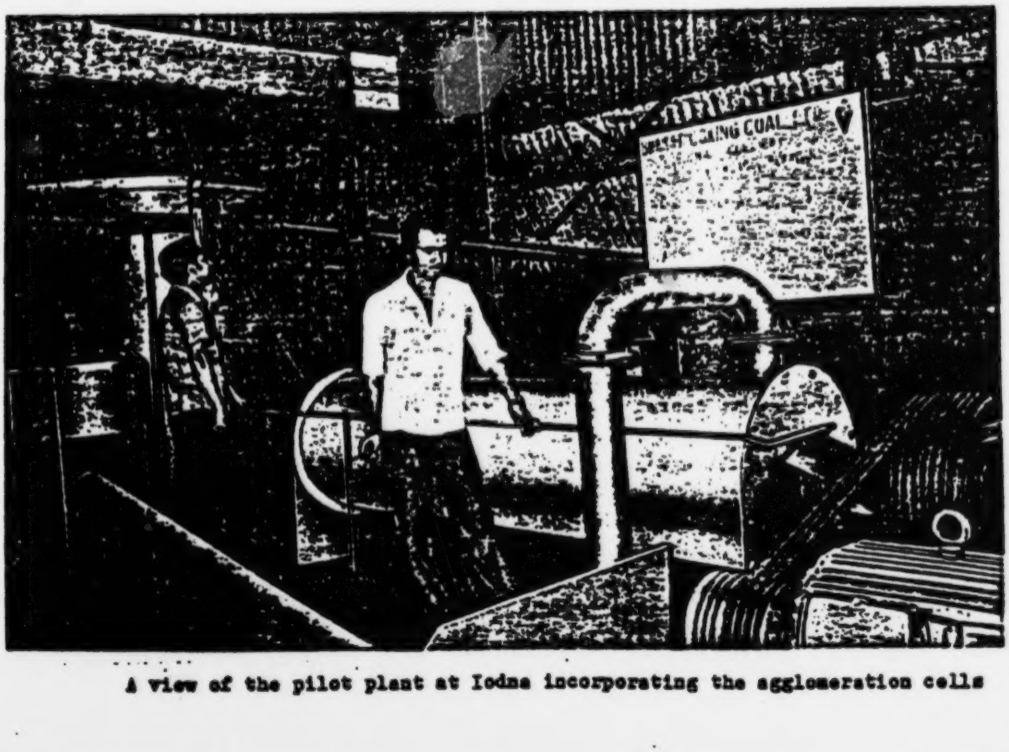


FIGURE 3.3.3-1

**Pilot plant set-up at Iodna: (India)**
**1 - distributor ; 2 - pH regulator; 3 - flocculant tank; 4 - thickener; 5 - conditioner; 6 - agglomeration cell; 7 - conditioning oil tank; 8 - bridging oil tank; 9 - water sump; 10 - sieve-bend and vibrating screen; 11 - pond for tailings; 12 - stock pile; 13 - pelletiser (provisional); 14 - bunker with grizzly; 15 - hopper; 16 - ball mill; 17 - slurry sump**



**A view of the pilot plant at Iodna incorporating the agglomeration cells**

kilometre pipeline loop for testing an Integrated Pipeline and Coal Cleaning System (IPTACCS). This is a joint BHP/BPA project. The test facility is located at Stockton near Newcastle in New South Wales. The test unit flowsheet is shown in Figure 3.3.4-1.

### 3.3.5 B.C. Research Pilot Plant (ACOP Process)

This plant was purchased from Esso Research in Calgary, and is basically a combination of processes for the 'deep cleaning' of fine coal, namely:

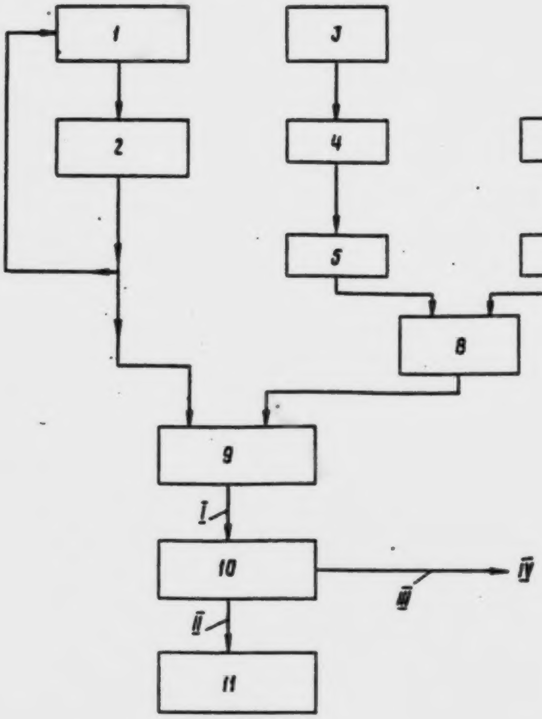
(a) Closed circuit wet ball mill grinding of coal fines to 85 percent minus 74 micron.
(b) Froth flotation of the product from the grinding circuit.
(c) Addition of hydrophobic, combustible organics to the flotation concentrate.
(d) Agglomeration/dewatering of the flotation concentrate to yield solid deep cleaned coal.

The process has a 0.5 - 1-tonne per hour capacity on a semi-continuous basis (see Figure 3.3.5-1).

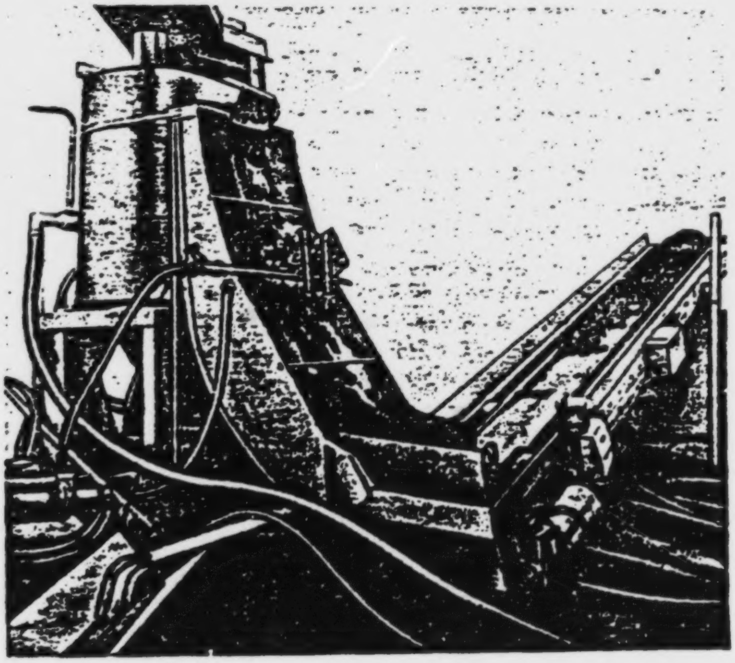
## 3.4 HIGH GRADIENT MAGNETIC SEPARATION (HGMS)

The cleaning of coal using High Gradient Magnetic Separation (HGMS) or Wet High Intensity Magnetic Separation (WHIMS) is based on the fact that most of the mineral matter in coal is weakly magnetic (paramagnetic) while the true coal particles are practically non-magnetic (diamagnetic). If coal is pulverized to a sufficient degree, a separation of paramagnetic and diamagnetic particles may be made by passing it through a strong electromagnetic field.

FIGURE 3.3.4-1 - BHP PILOT PLANT (AUSTRALIA)



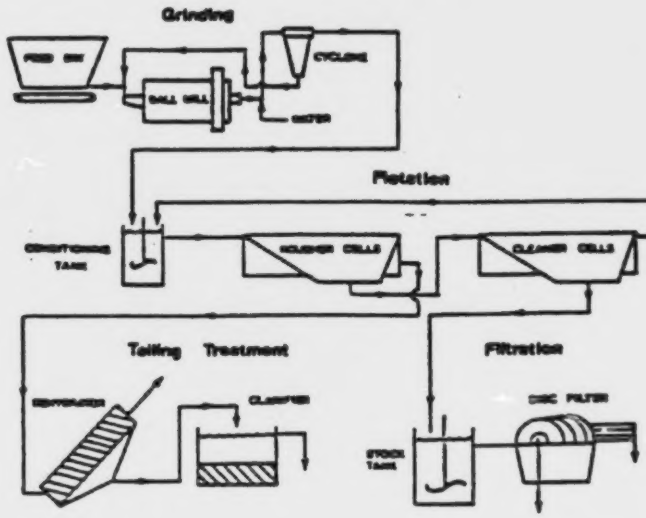
Process flow diagram for selective agglomeration:
1 - refuse slurry pond; 2 - suction pump; 3 - oil tank; 4 - pump; 5 - flowmeter;
6 - water; 7 - flowmeter; 8 - ultrasonic homogeniser; 9 - stirred tank agglomerator;
10 - curved dewatering screen; 11 - tailings for disposal
I.- overflow; II - underflow; III - overflow; IV - agglomerated coal product conveyed to stockpile



Pilot scale selective agglomeration plant

FIGURE 3.3.5-1

B.C. RESEARCH DEEP COAL CLEANING PILOT PLANT FLOWSHEET


Grinding
FEED BIN
CYCLONE
BALL MILL
WATER
Flotation
CONDITIONING TANK
ROUGHER CELLS
CLEANER CELLS
Tailing Treatment
Filtration
CLARIFIER
DISC FILTER
STOCK TANK

### 3.4.1 Separation Units

Pilot scale and commercial processes were developed in the late 1960s in the China clay industry, for the wet separation of weakly magnetic contaminants (iron pyrite, titanium oxide, etc.) from kaolin clay to upgrade its quality and brightness. Equipment used for pilot plant scale coal cleaning has mostly been developed from the equipment used by the China clay industry, but some equipment exists which has been specifically developed for coal. The principal types of equipment in use are:

#### (a) The Cyclic Electromagnetic HGMS Unit

This is a batch (cyclic) process (Fig. 3.4.1-1) consisting of energizing coils surrounded by an iron enclosure. The coils in turn enclose a cylindrical working volume packet with fine strands of strongly ferromagnetic materials (e.g., ferritic stainless steel wool). The ferromagnetic packing materials increase and distort the field in their vicinity. The coal is fed in slurry-form, and the variables investigated in testing this separator have been:

- Effect of field intensity
- Residence time
- Separator throughput
- Effect of dispersants on separation
- Effect of pH on separation
- Packing density
- Coal particle size
- Coal type.

The following institutions have reported carrying out coal separation work with this equipment:

- MIT and General Electric (Bench)

- Auburn University (Bench and Pilot)
- Indiana University (Pilot)
- DOE (Bench)
- Michigan Tech (Pilot)
- Sala Magnetics (Bench and Pilot).

(b) The Cyclic Superconducting HGMS Unit (Figure 3.4.1-1)

A similar principle to the electromagnetic unit, but using a coil winding of nobelium-titanium alloy in a helium container. A higher field intensity is generated to provide greater selectivity.

(c) Carousel Electromagnetic HGMS Unit

To overcome the inconvenience of batch operations, a continuous HGMS unit using a rotating multiple matrix system was developed. The basic working element of such a separator is a revolving magnetizable ring (carousel). Multiple separator matrices are mounted in the ring which passes continuously through a magnet station which is an elongated and steel-enclosed solenoid. Separation takes place in the matrix ring while it is passed through the magnetic station. Magnetic particles are captured in the matrix and carried out of the magnet station to the rinse and flush stations by the rotation of the matrix ring. The unit can be operated in a wet or dry phase. Extensive pilot plant testing with this unit has been carried out at Oak Ridge National Laboratory (Figures 3.4.1-2, 3.4.1-3 and 3.4.1-4).

(d) Continuous Superconducting HGMS Unit

In this continuous unit, the reciprocating double-matrix system is designed such that when one separator matrix has

## FIGURE 3.4.1-1

## CYCLIC ELECTROMAGNETIC HGMS UNIT

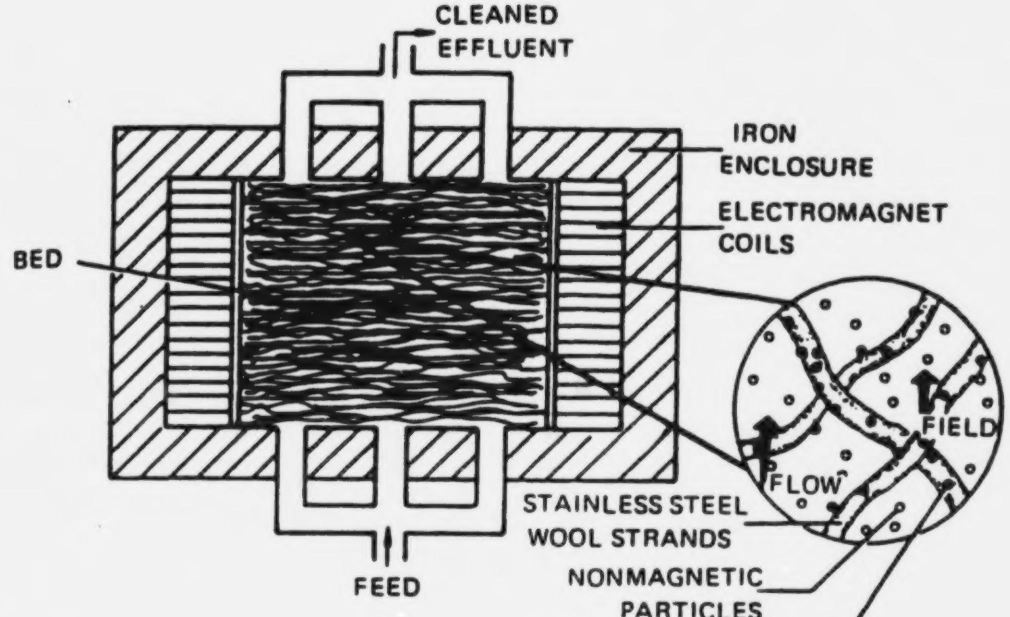
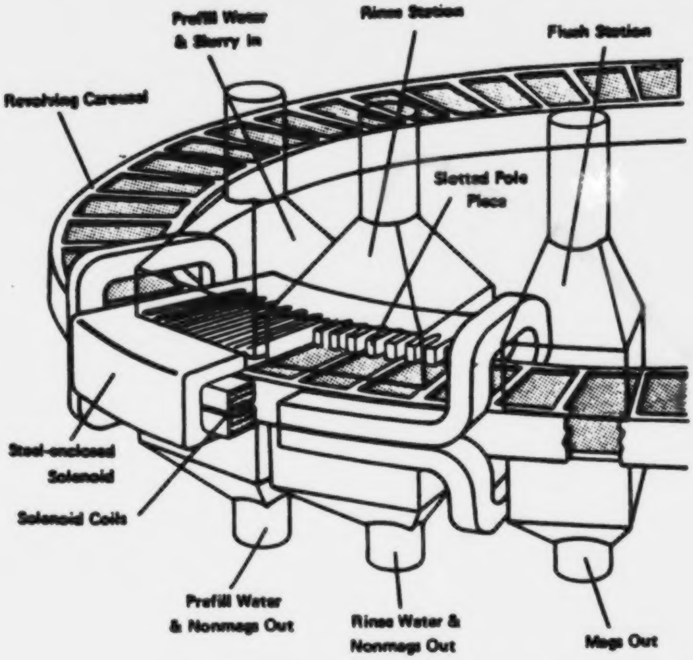

CLEANED
EFFLUENT
IRON
ENCLOSURE
ELECTROMAGNET
COILS
BED
FIELD
FLOW
STAINLESS STEEL
WOOL STRANDS
NONMAGNETIC
PARTICLES
FEED
MAGNETIC PARTICLES

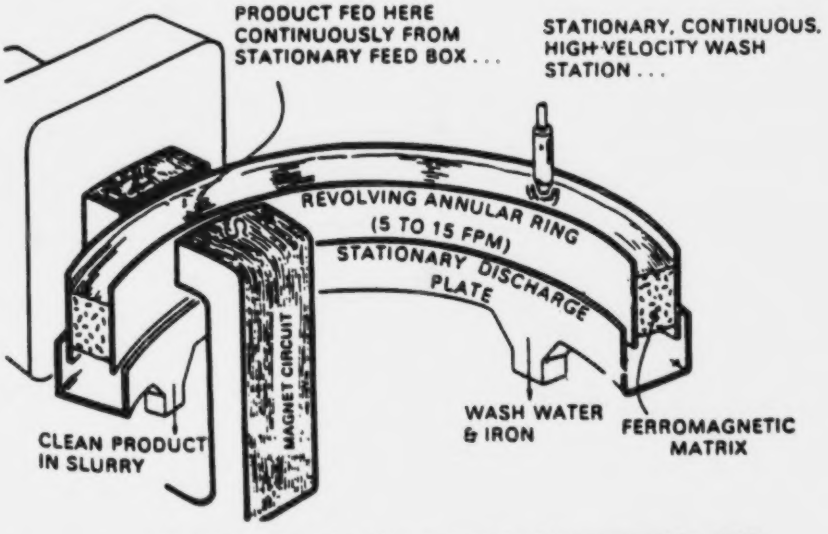
*Figure 4.1* A cyclic electromagnetic HGMS unit. (From Ref. 74. © 1976 IEEE.)

FIGURE 3.4.1-2


Prefill Water & Slurry In
Rinse Station
Flush Station
Revolving Carousel
Slotted Pole Piece
Steel-enclosed Solenoid
Solenoid Coils
Prefill Water & Nonmags Out
Rinse Water & Nonmags Out
Mags Out

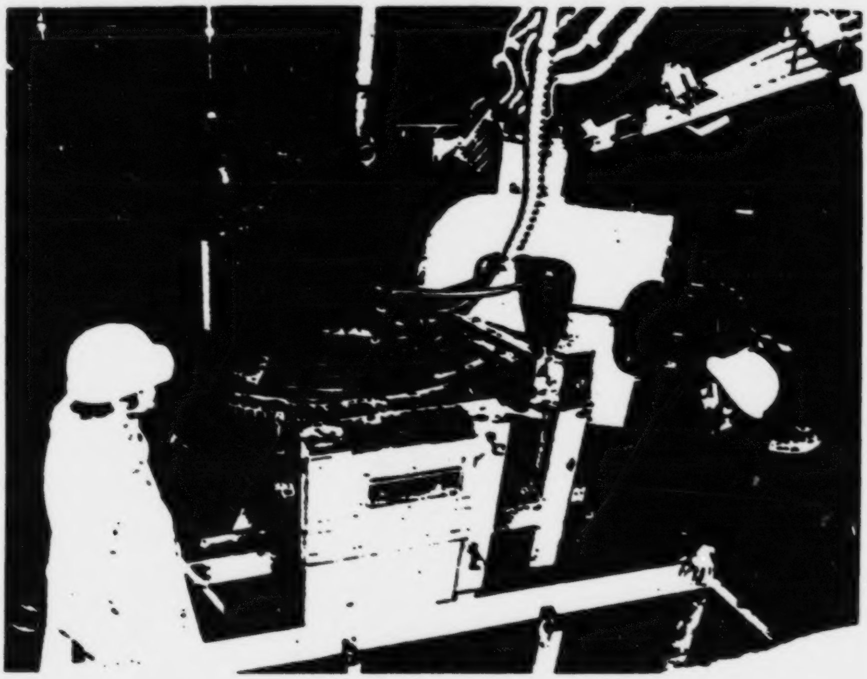
A cutaway view of a large-scale carousel separator. (From Ref. 73. © 1979 IEEE.)

FIGURE 3.4.1-3


PRODUCT FED HERE CONTINUOUSLY FROM STATIONARY FEED BOX . . .
STATIONARY, CONTINUOUS, HIGH-VELOCITY WASH STATION . . .
REVOLVING ANNULAR RING (5 TO 15 FPM)
STATIONARY DISCHARGE PLATE
MAGNET CIRCUIT
CLEAN PRODUCT IN SLURRY
WASH WATER & IRON
FERROMAGNETIC MATRIX

The basic elements of a carousel electromagnetic HGMS unit. (From Ref. 41.)

## FIGURE 3.4.1-4



A pilot-scale carousel separator used for desulfurization of dry pulverized coal by the Oak Ridge National Laboratory.

become saturated with the attracted magnetic materials in the feed stream, a second matrix is automatically inserted into the magnetic field at the same time that the first matrix is being moved outside of the magnetic field for its attracted materials to be flushed off.

### (e) Continuous Quadrupole HGMS Unit

These units employ specially designed magnetic structures that do not use matrix packing material. The feed stream is introduced through the upper portion of a centre tube [Figures 3.4.1-5a) and 3.4.1-5b)]. The magnetic particles are radially deflected through the gap and into the lower annulus formed between the two tubes.

### (f) Continuous Superconducting Quadrupole HGMS Unit

This separator consists of a superconducting quadrupole magnet installed in a vertical cyclindrical cyrostat with a hollow central portion, and a specially-designed curved channel for mineral slurry and wash water stream placed around the outer circumference of the cryostat.

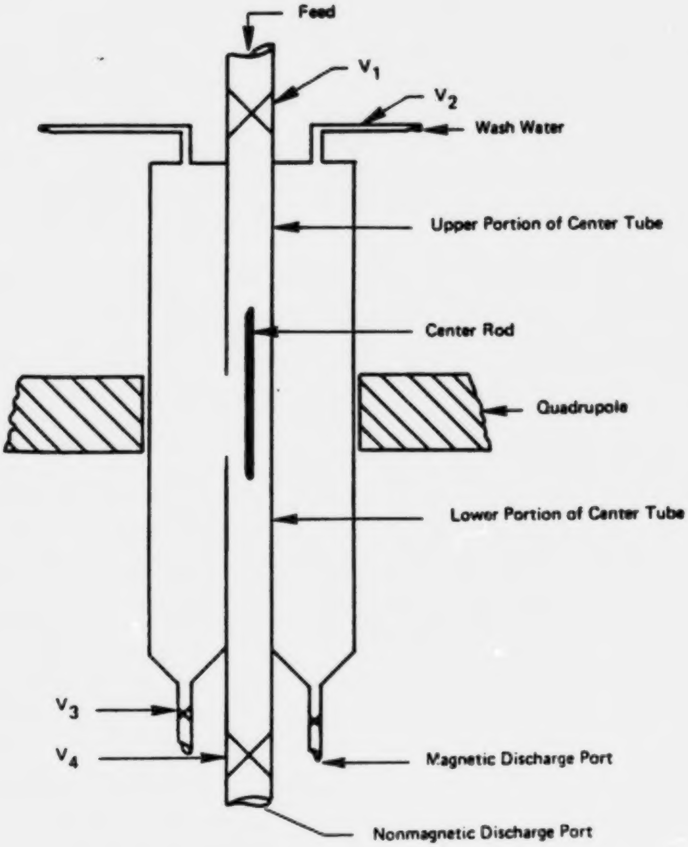
## 3.4.2 Physical Pre-Treatment Before HGMS

### (a) Gravity Separation

Advantages

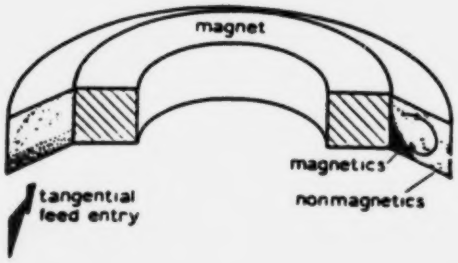
- Fine grinding for mineral impurity liberation can be delayed until mid-point through the beneficiation system.
- A gravity separation would remove a substantial amount of the non-magnetic ash-forming minerals which could not be removed by the magnetic separator.

FIGURE 3.4.1-5a)


Feed
$V_1$
$V_2$
Wash Water
Upper Portion of Center Tube
Center Rod
Quadrupole
Lower Portion of Center Tube
$V_3$
$V_4$
Magnetic Discharge Port
Nonmagnetic Discharge Port

A schematic diagram of a prototype quadrupole separator built by the Bethlehem Steel Corporation. (From Ref. 3.)

FIGURE 3.4.1-5b)


magnet
magnetics
nonmagnetics
tangential feed entry

A cutaway view of the quadrupole magnet and curved channel shown in Fig. 4.9. (From Ref. 10. © 1976 IEEE.)

- A gravity separator would also remove some of the very weakly magnetic sulphur-bearing and ash-forming minerals which could not be efficiently removed by the magnetic separator.

Disadvantages - Unless all magnetite is removed from the coal, interference could take place in the HGMS unit.

### (b) Froth Flotation

Although conventional froth flotation is used effectively to remove high ash material from coal, it does little to remove sulphur. Pilot plant tests have been carried out to use HGMS as a supplementary process to remove the weakly magnetic pyrite from the froth flotation clean coal.

### (c) Microwave Treatment (Dielectric Heating)

At a suitable range of radiation frequency of microwaves, pyrite can be preferentially heated to very high temperatures in the presence of hydrocarbon constituents of coal. This selective heating partially converts the pyrite to strongly magnetic compounds of iron. This conversion occurs with little or no significant loss of coal volatile matters, and is considered beneficial in increasing the subsequent efficiency of the magnetic separation in removing pyrite from coal. An apparent advantage of using microwave treatment for enhancing the magnetic properties of pyrite is that it is not necessary to crush the coal in order for the pyrite to be responsive to the electromagnetic radiation and to be selectively heated. The coarser the pyrite, the more readily it will be selectively heated. Grinding to liberate pyrite from coal could, therefore, be carried out after dielectric heating.

(d) Thermal Treatment

Some work has been carried out for thermally enhancing the magnetic susceptibility of sulphur-bearing minerals in coal, particularly pyrite. The object of the test work carried out has been to convert the surface of pyrite ($FeS_2$) to other highly paramagnetic and ferrimagnetic compounds such as pyrrhotite ($Fe_7S_8$) and magnetite ($Fe_3S_4$), thereby rendering such grains more amenable to magnetic separation using conventional low-intensity and low-gradient magnetic separation. Mixed results have been obtained including some adverse effects.

(e) Magnetic Fluids

A magnetic fluid consists of a dispersed phase of colloidal particles of magnetically susceptible material (e.g., magnetite). Each particle is coated with a sheath of dispersing agent (e.g., oleic acid), distributed throughout a continuous phase of carrier liquid (e.g., kerosene). These fluids are able to impart magnetic susceptibility to normally non-magnetic particles. Magnetic fluids are stable, reasonably inexpensive and responsive to magnetic forces. Experiments have shown that such fluids are strongly attracted to the surface of organic coal constituents.

Test work has been carried out at the Colorado School of Mines Research Institute using:

| | | |
|---|---|---|
| - An organic fluid | : | Kerosene/oleic acid |
| - Aqueous fluids | : | Water/lauric acid |
| | : | Water/dodecylomine. |

Magnetic fluids have been applied to both wet and dry processes. The magnetic fluid application differs. In the wet process, the coal feed should be immersed in say a mixing tank, in the dry process it is applied by a spray.

### 3.4.3 Chemical Treatment Before HGMS

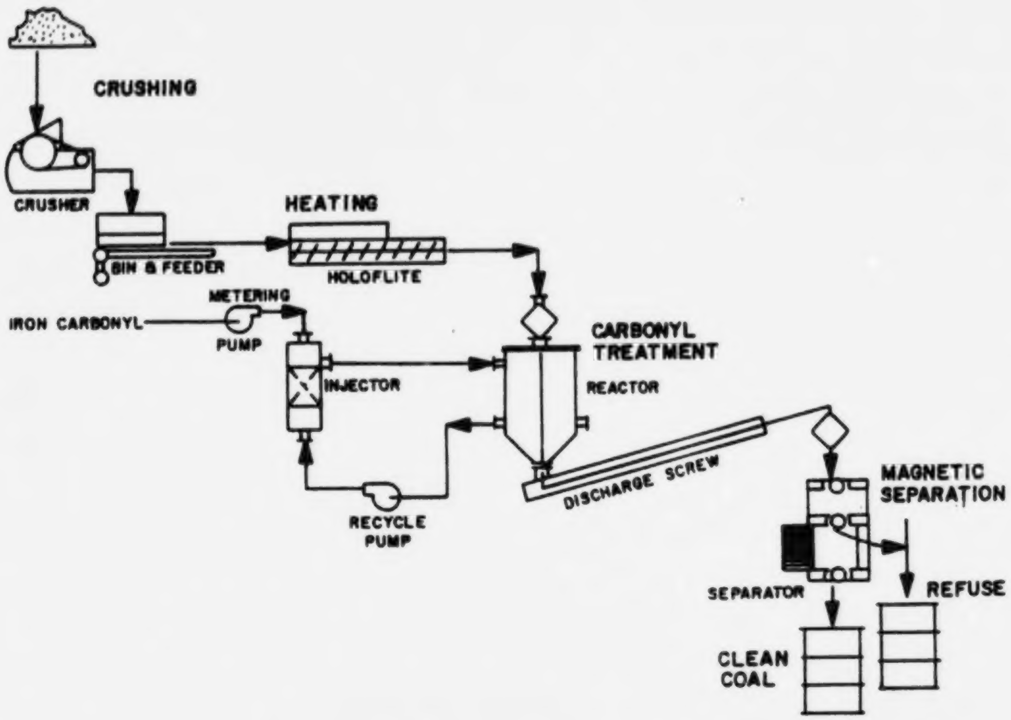
Chemical reactions can convert pyrite to more magnetic compounds of iron, so as to enhance magnetic susceptibility. Generally, the process has not been successful, with the possible exception of the Magnex process. This process is a dry physiochemical method which involves a chemical treatment of moderately crushed coal by iron carbonyl vapour followed by dry magnetic separation. The iron carbonyl selectively decomposes on the surfaces of ash-forming minerals to form strongly magnetic crystallites of iron. It also selectively reacts with pyrite to form a strongly magnetic pyrrhotite-like material. However, iron carbonyl will not react or deposit on the surfaces of organic coal constituents.

The process was developed by Hazen Research, Inc. in Colorado. Typically, the coal is crushed to minus 14 mesh and heated to 170 degrees Celcius in a Holoflite dryer. The iron carbynol is introduced into a reactor and the product submitted to dry magnetic separation (Figure 3.4.3-1).

### 3.4.4 Commercial Separators Available (Pilot Scale)

- Boxmag Rapid WHIMS and HGMS Pilot Plant Separators.
- Carousel Electromagnetic Pilot Scale HGMS Unit: Sala-HGMS, Model MK III.
- Colburn HGMS (Stainless Steel Sphere Matrix).
- Eries HGMS and WHIMS.

FIGURE 3.4.3-1


CRUSHING
CRUSHER
BIN & FEEDER
HEATING
HOLOFLITE
METERING
IRON CARBONYL
PUMP
INJECTOR
CARBONYL
TREATMENT
REACTOR
RECYCLE
PUMP
DISCHARGE SCREW
MAGNETIC
SEPARATION
SEPARATOR
REFUSE
CLEAN
COAL

A schematic diagram of the Magnex process pilot plant. (From Ref. 38. © 1979 IEEE.)

### 3.4.5 HGMS Test Data

Table 3.4.5-1 gives operational data in tabulated form for cyclic and carousel electromagnetic HGMS units treating coal slurries of selected eastern U.S.A. coals.

Table 3.4.5-2 gives desulphurization results with eastern U.S.A. coals treated dry using cyclic HGMS units.

## 3.5 SELECTIVE FLOCCULATION

The process is based on the preferential adsorption and bridging of an organic polymer flocculant on the particles of a selected mineral resulting in flocculation, while leaving the remainder of the suspension particles dispersed. The dispersion of certain components in the suspension, such as pyrite, may be further enhanced by using selective dispersants.

Considerable bench scale work has been carried out at Batelle on the separation of coal from pyrite by selective flocculation. Much less work has been devoted to the separation of coal and shale (some at Battelle in Ohio and some in eastern Europe). Little or no work appears to have been carried out at pilot plant scale for either form of separation.

## 3.6 CHEMICAL COMMINUTION AND CLEANING

### 3.6.1 Chemical Comminution

Chemical comminution involves the selective fracture of coal to liberate mineral matter by low molecular weight chemicals that are relatively inexpensive and recoverable. The fragmentation is strongly controlled by boundaries between maceral and mineral matters, resulting in greater mineral matter (especially pyritic sulphur) liberation than mechanical crushing to a similar size.

## TABLE 3.4.5-1

Estimated Processing Capacities of Typical Cyclic and Carousel Electromagnetic HGMS Units for Desulfurization of Water Slurries of Selected Eastern Coals

| Coal type (data reference) | Flow velocity, cm/sec | Solids concentration, g/cm$^3$ | Volumetric matrix loading, g/cm$^3$ | Capacity per magnetic head, metric ton/hr | | |
|---|---|---|---|---|---|---|
| | | | | Cyclic[a] SALA/HEMF No. 214-30-19 | Linear[a] SALA/HGMS No. 160 | Carousel[a] SALA/HGMS No. 480 |
| 1. Illinois No. 6 (Old Ben), 70% −200 mesh [106] | 0.5 | 0.30 | 0.37 | 5.9 | 13.4 | 8.1 |
| 2. Pennsylvania Lower Freeport (Canterbury) 70% −200 mesh [106] | 0.5 | 0.30 | 1.75 | 12.8 | 19.3 | 11.7 |
| 3. Pennsylvania Sewickley, 70% −200 mesh [106] | 0.9 | 0.30 | 1.50 | 20.4 | 33.0 | 20.0 |
| 4. Pennsylvania Upper Freeport (Delmont) −60 mesh [57] | 1.36 | 0.30 | 0.50[b] | 15.3 | 29.0 | 17.6 |
| 5. West Virginia Pittsburgh No. 8, −14 mesh [82] | 4.0[b] | 0.30 | 0.50[b] | 27.0 | 85.4 | 51.8 |

[a] Manufactured by Sala Magnetics, Inc.

[b] Estimated values.

*Source*: Ref. 106.

## TABLE 3.4.5-2

Reported Cyclic HGMS Tests for Desulfurization of Dry Pulverized Coal

| Process number | Experimental approach | Typical field intensity, kOe | Typical feed coal particle sizes | Coals used | Refs. |
|---|---|---|---|---|---|
| 1 | Conventional gravity feeding | 20 | | Indiana No. 5 and No. 6 | [66] |
| 1A | Vibration-assisted gravity feeding | 20 and 64.5 | 60 × 0 mesh, −200 +200 mesh | Pennsylvania Upper Freeport | [57] |
| 1B | Gravity feeding assisted by slow-velocity air flow (ORNL/SALA process) | 20 | CSF/PSFR[a] | Kentucky No. 9 and Pennsylvania Lower Freeport | [24] |
| 2 | Upward air-entrained flow | 20 | CSF/PSFR | Same as above | [24] |
| 2A | Upward air-entrained flow | 20 | UBF[b] | Pennsylvania Upper Kittanning | [65] |
| 2B | Downward air-entrained flow | 20 | −60 mesh | Pennsylvania Upper Freeport | [57] |
| 3 | Auburn/ORNL electromagnetic fluidized-bed[c] | 20 | CSF/PSFR | Pennsylvania Upper Freeport, Lower Freeport, Upper Kittanning and Lower Kittanning | [14,46, 51,53] |
| 4A | Auburn/NEPSCO electromagnetic fluidized-bed[c] | 20 | UBF | Pennsylvania Upper Kittanning | [54,65] |
| 4B | Auburn/NEPSCO superconducting fluidized-bed[c] | 40 to 50 | UBF | Pennsylvania Upper Kittanning and Upper Freeport, Ohio/ Pittsburgh No. 8 | [99] |

[a] CSF/PSFR: classified size fractions per preseparation fines removal (e.g., −100 +200 mesh, −200 +325 mesh, −100 mesh +10 μm, −200 mesh +10 μm).

[b] UBF: utility boiler feed coal, typically 80% −200 mesh.

[c] Process 3 uses a novel expanded fluidized-bed separator matrix, while processes 4A and 4B employ new straight-bed separator matrices with unique partial product recycle techniques.

Although a number of chemicals have some comminution ability, the chemicals that appear to have the greatest effect are ammonia (gaseous or liquid) and methanol. The variables that effect comminution are:

(a) Pressure (if ammonia gas is used)
(b) Comminution time
(c) Coal properties.

The majority of work carried out to date has been at Syracuse Research Corporation. The work has been performed at bench scale on batch processes. On a pilot or commercial scale, the following steps are required:

(a) Treating raw minus 1½-inch coal with a chemical agent (ammonia as a gas, liquid or aqueous solution).
(b) Removing the adsorbed ammonia from the coal (by hot-water washing).
(c) Recovering ammonia from the wash water for recycling by distillation followed by compression, with or without liquefaction.

Suggested flowsheets for continuous plants using ammonia vapour (Figure 3.6.1-1) and ammonia liquid (Figure 3.6.1-2) are shown.

### 3.6.2 Chemical Cleaning (Leaching)

A number of chemical cleaning processes are under development at the bench scale, but only a few have been attempted at pilot plant scale. While all the processes are designed to remove most of the inorganic sulphur from coal, not all will reduce the organic sulphur content or ash content to the same extent. The processes also differ in how they affect other properties of the coal and in regard to the chemical agents, reactions and conditions employed. Some of the major processes at the bench

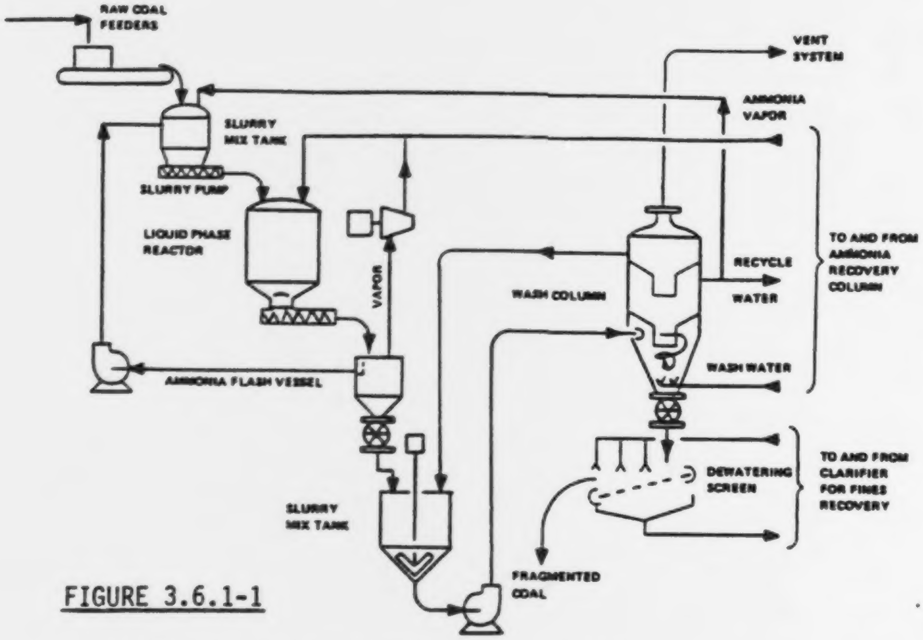

RAW COAL FEEDERS
SLURRY MIX TANK
SLURRY PUMP
LIQUID PHASE REACTOR
VAPOR
AMMONIA FLASH VESSEL
SLURRY MIX TANK
VENT SYSTEM
AMMONIA VAPOR
WASH COLUMN
RECYCLE WATER
WASH WATER
TO AND FROM AMMONIA RECOVERY COLUMN
DEWATERING SCREEN
TO AND FROM CLARIFIER FOR FINES RECOVERY
FRAGMENTED COAL

FIGURE 3.6.1-1

Flowsheet of a continuous chemical comminution process using ammonia liquid (slurry feed design).

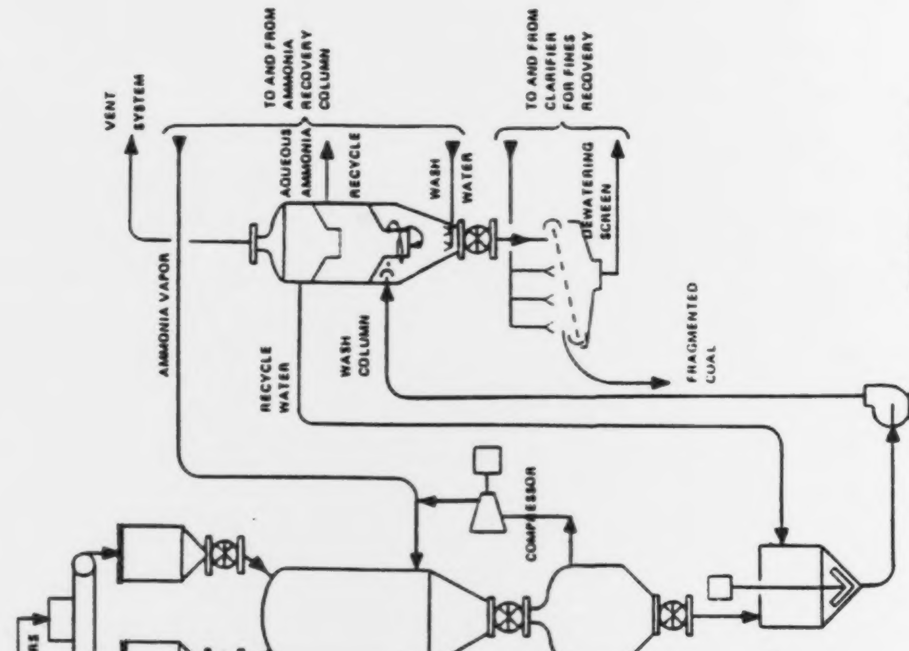

RAW COAL
FEEDERS
LOCK HOPPERS
VAPOR PHASE REACTOR
DEVOLATILIZER
COMPRESSOR
SLURRY MIX TANK
AMMONIA VAPOR
RECYCLE WATER
WASH COLUMN
VENT SYSTEM
AQUEOUS AMMONIA
RECYCLE
WASH WATER
TO AND FROM AMMONIA RECOVERY COLUMN
TO AND FROM CLARIFIER FOR FINES RECOVERY
DEWATERING SCREEN
FRAGMENTED COAL

FIGURE 3.6.1-2

Plowsheet of a continuous chemical comminution process using ammonia vapor (lock hopper feed design).

scale are:

(a) Ledgemont Oxygen Leaching Process

There are two versions of the process: (1) ground coal leached with a hot acidic solution under pressure, and (2) ground coal leached with ammonia. The ammonia leach appears to remove organic as well as pyritic sulphur. Physical cleaning of the coal is the primary stage, followed by grinding to 150 micron. Laboratory scale work on this process has been carried out at Kennecott and by Hydrocarbon Research, Inc. A 2 to 5-ton per day pilot plant has been planned.

(b) PETC Oxydesulphurization Process

Similar to the Ledgemont process, but at more severe operating conditions, i.e., high temperatures and pressures and compressed air instead of oxygen. Raw coal was ground to 74 micron. Work on this process has been carried out at bench scale at the Department of Energy, Pittsburgh.

(c) Ames Wet Oxidation Process

Similar to both the Ledgemont and PETC processes, it differs in that it employs an alkaline leaching solution. The alkali improves the rate of extraction of pyritic sulphur and also assists the removal of organic sulphur. In addition, the alkaline system is much less corrosive towards materials of construction than the acidic system. Coal is ground to 74 micron and leached at 150 degrees Centigrade in oxygen at 14 atm. The coal preparation, leaching and product recovery steps for the Ames process are similar to those for the previously described processes.

Laboratory scale test work has been carried out on this process at the University of Iowa, although plans to install a pilot plant process have now been delayed.

### (d) ARCO Promoted Oxydesulphurization Process

This process is again similar to the Ledgemont and PETC processes, except that oxidation and leaching are conducted in a solution of an iron-complexing agent such as sodium oxalate which serves as a reaction promoter. The process removes most of the pyritic sulphur and iron from the coal and reduces the ash content significantly. It has reached the small pilot plant stage of development, work being carried out by EPRI and ARCO. The pilot plant is 0.25 tonnes per hour.

### (e) Meyers/Gravichem Process

The Meyers process has been developed at TRW, Inc., and utilizes a hot solution of ferric sulphate to extract most of the pyritic sulphur from the coal. It has been investigated quite thoroughly, and several key steps have been demonstrated in a test plant capable of treating 100-300 kilograms per hour. The Gravichem process is a modification whereby the acidic ferric sulphate leach solution is used as a dense medium for gravity separation of the feed coal. This modification enables coal having a specific gravity of 1.3 or less to bypass the leaching step.

While the Meyers process has probably undergone the greatest development of any chemical cleaning process, it is unable to remove organic sulphur, and its cost is higher than physical cleaning. Little work is being carried out on the process at the present time.

### (f) JPL Chlorinolysis Process

In this process, pulverized coal is suspended in methylchloroform and treated with chlorine gas at 74 degrees Centigrade. Tests have been carried out at bench scale using 2-kilogram batches.

### (g) KVB Process

This process involves treating dry pulverized coal at 100 degrees Celsius with a gas stream containing nitrogen dioxide and oxygen under atmospheric pressure. Development of the process is at the laboratory stage.

### (h) Batelle Hydrothermal Coal Process

The hydrothermal process involves mixing finely ground coal with a caustic solution containing 10 percent (weight) sodium hydroxide and 2-3 percent (weight) calcium hydroxide, pre-heating the mixture, reacting and leaching at elevated temperature and pressure, cooling, filtering, washing and drying. It also includes regeneration of the spent leachant and recycle of the alkali. The extraction of over 90 percent of the pyritic sulphur from a large number of coals and up to 50 percent of the organic sulphur from certain coals, have been demonstrated in laboratory and bench scale equipment. A small continuous flow bench scale reactor has been developed treating 10 kilograms per hour. Little work is being carried out in this area at the present time.

### (i) AMAX - Two-Stage Caustic and Acid Leaching

AMAX Research and Development, Inc. has a chemical cleaning pilot plant at Golden, Colorado (Figure 3.6.2-1). Current

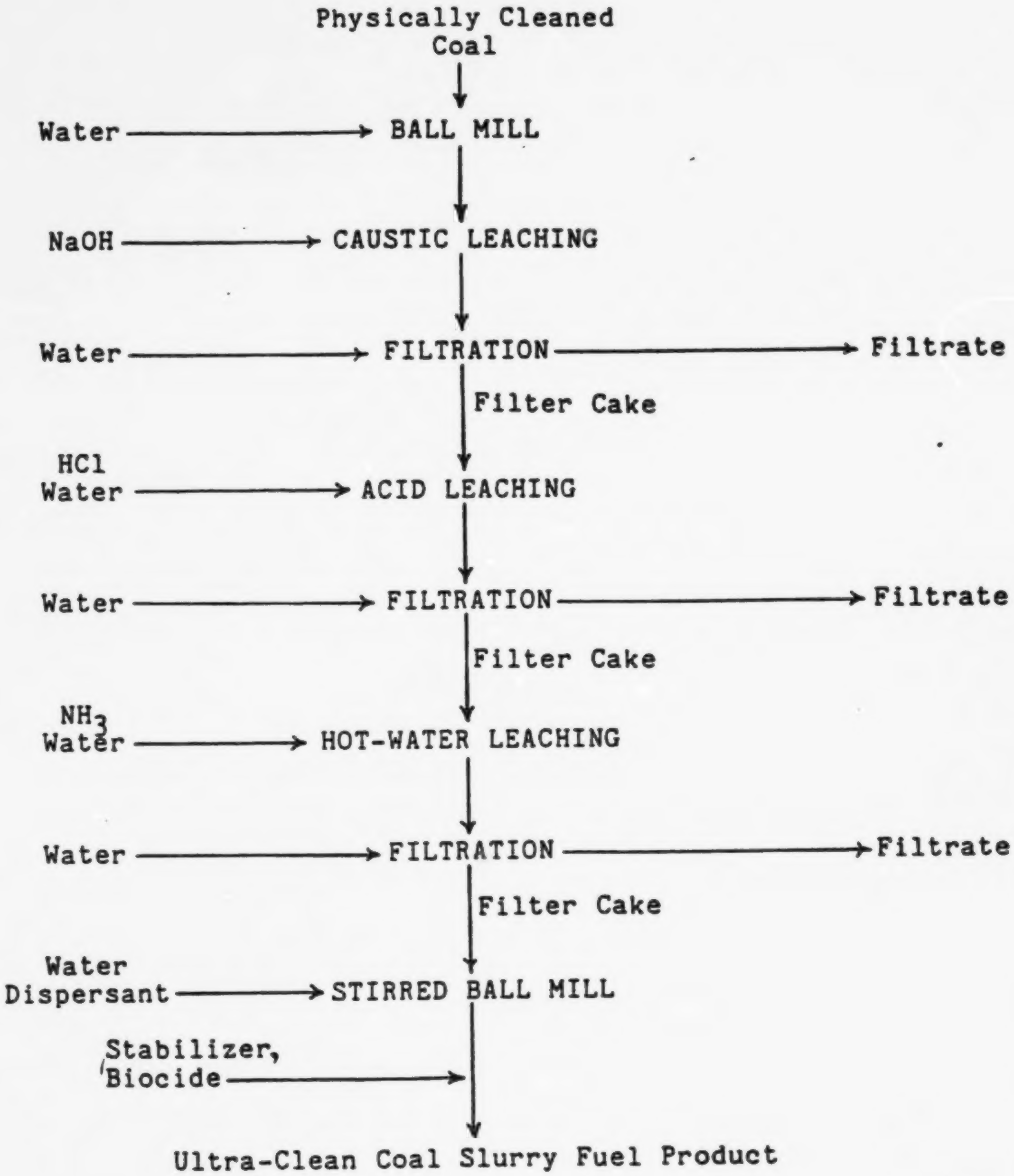

Physically Cleaned Coal
Water
BALL MILL
NaOH
CAUSTIC LEACHING
Water
FILTRATION
Filtrate
Filter Cake
HCl
Water
ACID LEACHING
Water
FILTRATION
Filtrate
Filter Cake
$NH_3$
Water
HOT-WATER LEACHING
Water
FILTRATION
Filtrate
Filter Cake
Water
Dispersant
STIRRED BALL MILL
Stabilizer,
Biocide
Ultra-Clean Coal Slurry Fuel Product

FIGURE 3.6.2-1

Process for Ultra-Clean
Coal Slurry Fuel Manufacture

work has been carried out on coals pre-cleaned by froth flotation and by heavy liquids separation. The process appears to work well in the removal of sulphur and ash, and AMAX is currently producing ultra-low ash coals by this process for the coal-water slurry burning tests at DOE, Morgantown.

#### (j) G.E. Microwave Treatment Process

By first applying sodium hydroxide to the coal and then treating it with microwave energy, sulphur removal has been increased to as much as 95 percent for pyritic sulphur, and 60 percent for organic sulphur. Following the sodium hydroxide addition to the powdered coal, the product is dewatered and irradiated with microwave energy under a nitrogen atmosphere. The coal is then washed to remove soluble sulphur and finally dried.

The developers of the microwave treatment process have been planning a 1-ton per day pilot plant.

## 3.7 ELECTROSTATIC SEPARATION

Electrostatic separation of finely divided matter is the interaction between an external electric field and the electric charges acquired by the various particles. While the external electric field can be easily produced and controlled, the selective charging of the particles, especially combustible matter such as coal, requires the developmental work.

### 3.7.1 Type of Electrification/Charging

There are three types of selective electrification processes likely to find application in fine coal cleaning, namely:

- Triboelectrification
- Conductive Induction Charging
- Ionic and/or Electronic Bombardment from a Corona Generator in combination with Conductive Discharges.

(a) Triboelectrification

In simple terms, triboelectrification is the transfer of electric charge from a surface to a particle by direct contact.

(b) Conductive Induction Charging

A positive high-voltage electrode attracts or 'induces' greater negative charges on highly conductive particles than on insulating particles or those of lower conductivity.

(c) Corona Charging

Ionic or electronic bombardment from corona wires is used to charge the particles. Once out of the corona field, conductive particles rapidly lose their charge, and the charge on insulating particles remain.

### 3.7.2 Electric Field

Once the particles are charged selectively, they may be allowed to fall freely under gravity forces in an applied horizontal electric field, or they may be introduced into a fluidized bed which is traversed by an electric field.

### 3.7.3 Equipment

The electrostatic beneficiation of coal is still very much in the developmental stage. Much of the work is being carried out at the University of Western Ontario. They recommend the following equipment as having good potential for a pilot plant scale testing:

(a) Electrostatic Separation Tower (Figure 3.7.3-1)

The tower is built from acrylic sheeting. The top section contains a fluidized-bed charging system, where coal is triboelectrified. The fluidized bed is of acrylic tubing. The inside walls of the bed are lined with copper sheeting which has proved ideal for charging. The bed is fluidized by a porous plate grid of sintered stainless steel plate, which is, in turn, covered with a 400 mesh copper screen. The separation system consists of two parallel vertical electrodes (183 centimetres high, 44 centimetres wide, spaced 61 centimetres apart) which have collection baffles on the inside surface to collect particles sliding down the electordes. The coal particles, during their free-fall from the fluidized bed above, migrate towards the electrodes under the influence of the electric field. They are collected either on the baffles located on the electrodes or in 12 troughs or trays placed at the bottom of the tower. The troughs are 58 centimetres long and 5 centimetres wide, of aluminum construction, electrically insulated, and can be connected to an electrometer to measure the charge of the material collected in the tray. The tower is equipped with gas lines used to purge it and fluidize the charging bed with nitrogen because of the explosion potential of coal-air mixtures.

*Electrostatic Beneficiation of Coal*

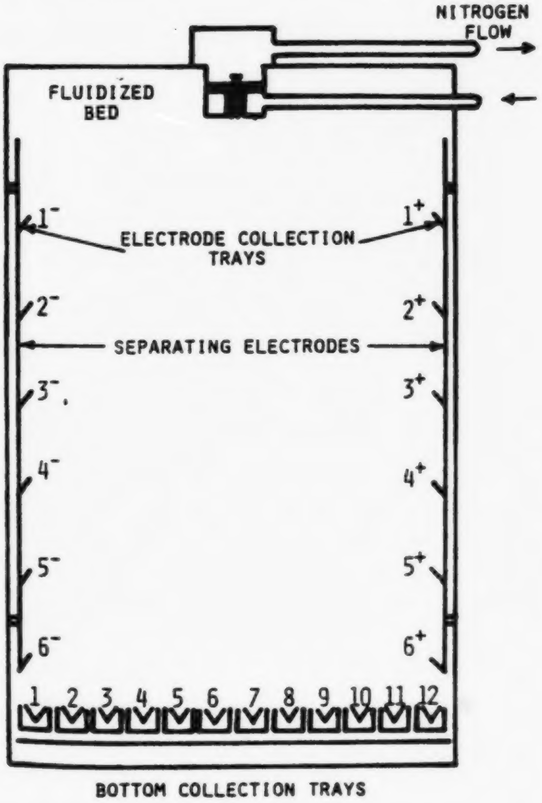

NITROGEN FLOW
FLUIDIZED BED
1⁻
1⁺
ELECTRODE COLLECTION TRAYS
2⁻
2⁺
SEPARATING ELECTRODES
3⁻
3⁺
4⁻
4⁺
5⁻
5⁺
6⁻
6⁺
1 2 3 4 5 6 7 8 9 10 11 12
BOTTOM COLLECTION TRAYS

FIGURE 3.7.3-1

ELECTROSTATIC SEPARATION TOWER

(b) Dilute-Phase Electrostatic Loop (Figure 3.7.3-2)

The function of the loop is to charge particles by triboelectrification while in a suspension in an inert gas and then separate them. As coal particles are transported around the loop, they collide with the walls and with other particles. The loop is 8 metres high. Propulsion of the coal is obtained from two gas inducers powered by bottled nitrogen, which blows gas along the walls of the loop pipe to impart upward momentum to the solid-gas suspension.

## 3.8 TRUE HEAVY LIQUIDS SEPARATION

The use of a true heavy liquids (as opposed to suspensions such as magnetite in water) for coal cleaning was first demonstrated in the 1930s. The Dupont Company built a pilot plant in Pennsylvania to clean anthracite using organic liquids. The process was abandoned due to the extremely high liquid loss and the resulting toxic environment.

The advantages of using heavy liquids are:

(a) Viscosity considerations allow all size particles into the separator, i.e., there is no need to pre-size.
(b) A high degree of accuracy of separation.
(c) No water is added to the coal and refuse.
(d) Non-corrosive and non-abrasive character of heavy liquids.

The disadvantages to be overcome are:

(a) Moisture in the raw coal must be dealt with, otherwise it will cause problems with the heavy liquid.
(b) Heavy liquids are expensive and easily lost through evaporation.

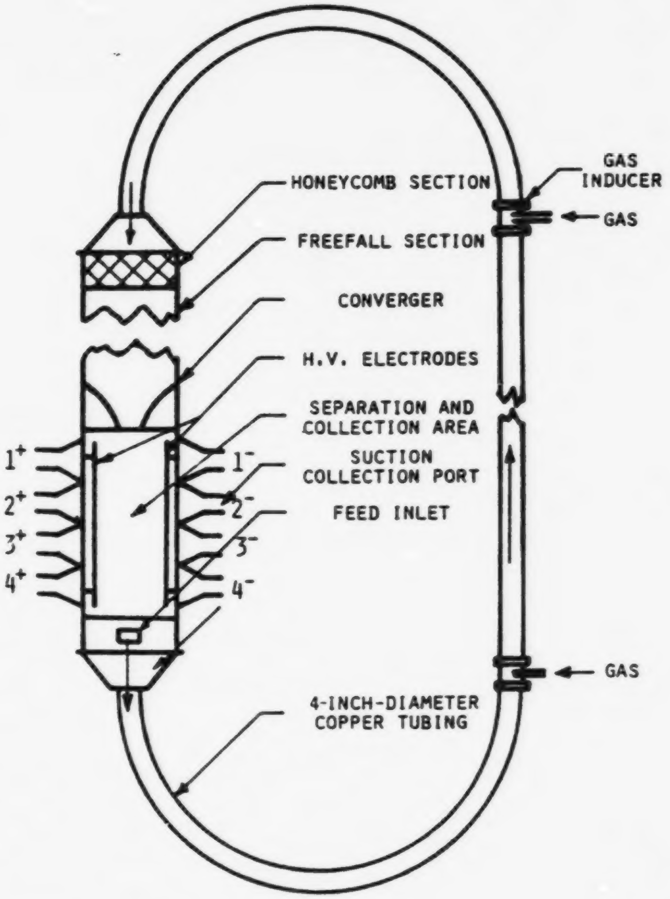

GAS
INDUCER
HONEYCOMB SECTION
GAS
FREEFALL SECTION
CONVERGER
H.V. ELECTRODES
SEPARATION AND
COLLECTION AREA
$1^+$
$1^-$
SUCTION
COLLECTION PORT
$2^+$
$2^-$
FEED INLET
$3^+$
$3^-$
$4^+$
$4^-$
GAS
4-INCH-DIAMETER
COPPER TUBING

FIGURE 3.7.3-2

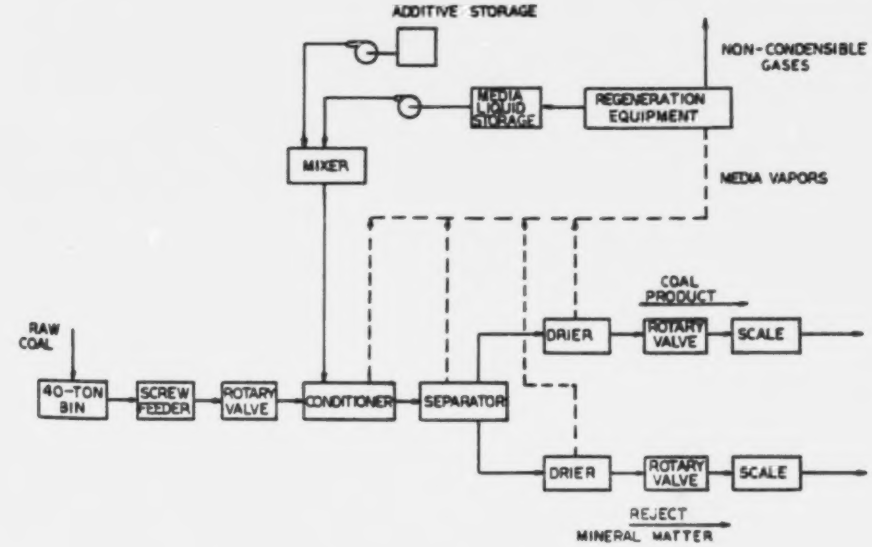
DILUTE-PHASE ELECTROSTATIC LOOP

A suitable heavy liquid for practical application should have the following properties:

(a) Low viscosity
(b) Low boiling point
(c) An appropriate density which can be readily varied from 1.25 - 1.70
(d) Unreactive with the material being separated
(e) Low heat of vaporization
(f) Inflammable
(g) Non-toxic
(h) Non-corrosive
(i) Inexpensive.

Heavy liquids for float/sink analysis have been obtained from the class of $C_1$-$C_3$ halohydrocarbons where the most common and characteristic of this group is carbontetrachloride. The establishment of an appropriate density between 1.2 - 2.0 is usually accomplished by mixing various combinations of these liquids or hydrocarbons, as long as the second liquid meets the cited criteria and the two are compatible with each other.

The Otisca process (Figure 3.8-1) uses a bath-type separator and treats raw coal down to zero. The heavy liquid used is $CCl_3F$. It is claimed that due to its viscosity and non-polarity, the velocity of separation of particles is very different from a heavy media separation, with the result that very fine particles are separated in the bath, as efficiently as coarse particles. It is also claimed that near-perfect separation is achieved: "...The simplicity of the solids stream treating all sizes from any maximum diameter down to zero, i.e., no screening, no fines removal, and no multiprocessing steps for the respective size ranges, is the principal reason that this process is inexpensive relative to the competitive processes."


ADDITIVE STORAGE
NON-CONDENSIBLE GASES
MEDIA LIQUID STORAGE
REGENERATION EQUIPMENT
MIXER
MEDIA VAPORS
COAL PRODUCT
RAW COAL
DRIER
ROTARY VALVE
SCALE
40-TON BIN
SCREW FEEDER
ROTARY VALVE
CONDITIONER
SEPARATOR
DRIER
ROTARY VALVE
SCALE
REJECT
MINERAL MATTER

Otisca process schematic drawing. (Data courtesy of Otisca Industries, Ltd.)

FIGURE 3.0-1

Surface moisture in the raw coal transfers to the shale in the reject. The heavy liquid is expensive, but it is claimed that there is total recovery resulting in the cost of the liquid being a capital cost rather than an operating cost. A proprietary additive is introduced with the raw coal (little information is given on the additive).

The products of separation are removed mechanically from the bath to their respective parting-liquid evaporators. Indirect-fired conductive evaporators (hot-water-heated hollow screws, operating at about 200 degrees Fahrenheit) raise the temperature of the products and vapourize all of the included parting-liquid (boiling temperature 74.9 degrees Fahrenheit). The products are ejected through their respective rotary seal valves back to ambient conditions. The process has been designed and constructed to be completely airtight so as to contain all of the heavy liquid vapour evolved during conditioning, separation and evaporation. This vapour is conducted through ducts, a particle filter and then to a gas recovery apparatus which converts all of that vapour back to the liquid state for reuse in the process. This is accomplished through a series of compression, condensation and sorption steps such that the remaining residues, principally non-condensible gases (air) which are eliminated from the system, are free of parting-liquid vapour. The regeneration system is controlled to operate under conditions to ensure that each unit process in the system is at a vacuum of about 0.2 inches of water. As a result, any system leakage results in an infiltration of air in the system rather than $CCl_3F$ vapour loss from the system. The parting-liquid condensate is essentially pure and is placed in a storage tank until it is required for conditioning raw coal.

Extreme care has been taken in system design and construction to reduce liquid and vapour losses to an absolute minimum.

Present design criteria established by pilot plant testing cite less than 0.25 pounds per raw coal ton as a typical vapour loss. Process emission loss from the mechanical equipment should account for less than 0.05 pounds per raw coal ton, while losses due to adsorption of the molecules into the coal matrix are less than 0.2 pounds per raw coal ton, or less than 100 ppm. This chloride residue resulting from using the parting-liquid is less than the existing chlorine concentration in coal of between 700-900 ppm. Pilot plant testing has also indicated that the additive consumption is in the range of 0.2 kilograms per raw coal tonne.

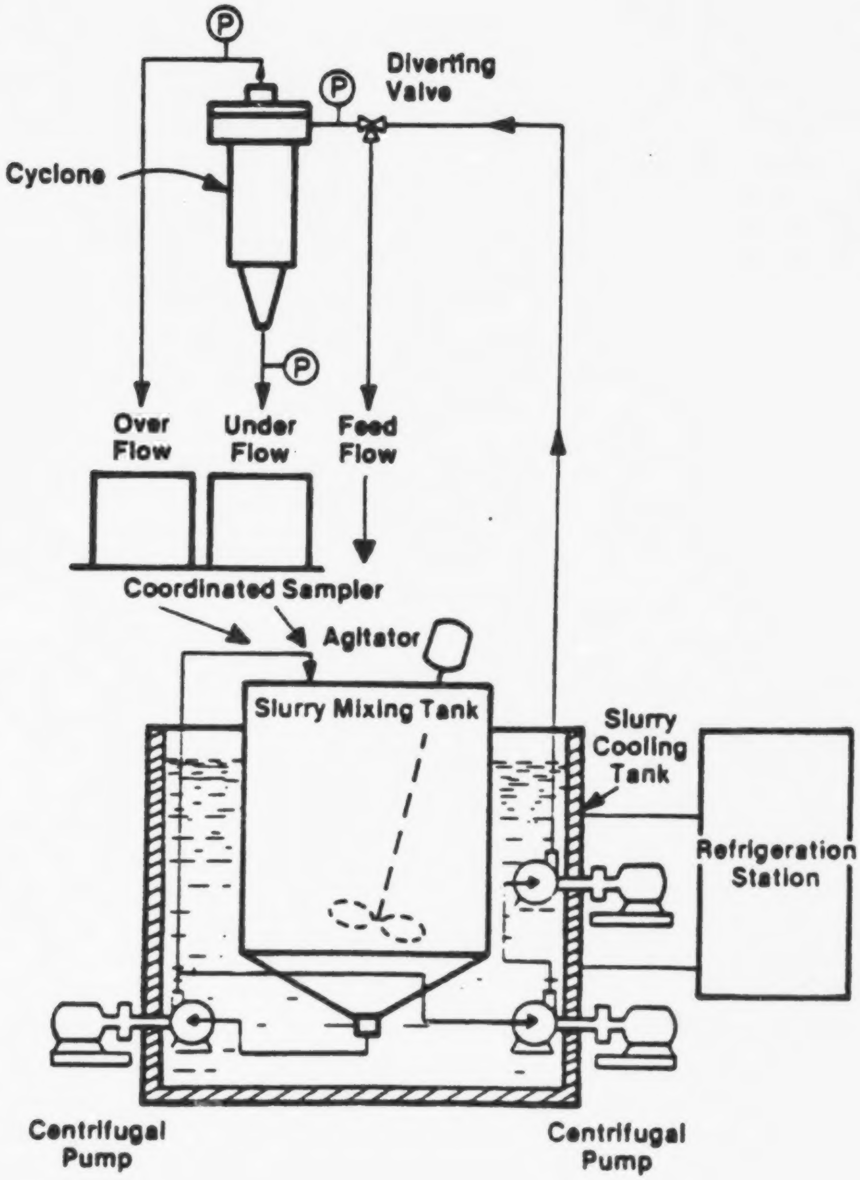
The DOE is planning to test a cyclone version of this process in their reassembled pilot plant, following test work carried out by Otisca on 1-inch and 2-inch cyclones in their pilot rig (Figure 3.8-2).

Other true heavy liquids that have been tested are solutions of monosaccharides and disaccharides. TRW, Inc. has several patents on this process.

Dow Chemicals has developed a proprietary process for the 'deep cleaning' of fine coal using the 'Dow Fine Coal Cleaning Process' and the 'Dow Solvent Recovery Technology' which can achieve less than 500 ppm residuals on the products. Although little detail is given on the process, the chlorinated solvents used are methylene chloride, 1,1,1 - trichloroethane, trichloroethylene and perchloroethylene.

## 3.9 AIR SEPARATION

Air separation has been used successfully on coarse coal (air jigs, air tables, etc.), but there has been limited work carried out on fine coal other than for size classification.


P
Diverting Valve
P
Cyclone
P
Over Flow
Under Flow
Feed Flow
Coordinated Sampler
Agitator
Slurry Mixing Tank
Slurry Cooling Tank
Refrigeration Station
Centrifugal Pump
Centrifugal Pump

Cyclone System Configuration

FIGURE 3.8-2

OTISCA - TRUE HEAVY LIQUID CYCLONE TEST PLANT

There is some potential, however, for the use of air to beneficiate pulverized coal. It has been reported that beneficiation has been achieved in air-swept mills treating lignite in Yugoslavia, and that further pilot scale studies are under way.

## 3.10 BIOLOGICAL LEACHING

Biological leaching has been used successfully in the treatment of acid mine water from coal mines. The organism Thiobacillus Ferro-oxidans derives its cellular energy from the oxidation of the ferrous portion of iron pyrite.

Bench scale research work has been carried out on processes for the biological leaching of the pyrite from pulverized coal. Reduction in sulphur content has been achieved; however, the process is, by its nature, a batch process and is highly unlikely to be developed in the near future to a pilot plant scale for fine coal beneficiation.

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## 4.0 DEEP CLEANING OF COAL: TEST PILOT PLANT SURVEY

## 4.1 DEPARTMENT OF ENERGY - PITTSBURGH

# KILBORN ENGINEERING (B.C.) LTD.

## INTER - OFFICE MEMORANDUM

FROM A. D. WALTERS

TO RECORD

DATE NOVEMBER 20, 1985

COPY TO

SUBJECT DEEP CLEANING

COPY TO

FILE No. 7813-15

COPY TO

### PHONE CALL TO AL DEURBROUCK - DOE, PITTSBURGH

1. DOE COAL PREPARATION RESEARCH

They are currently reassembling their pilot plant equipment tests (deep-cleaning) of 'true' heavy liquids in cyclones. The liquids will be Freon-based. They also plan to carry out small scale testing of HGMS with the addition of Tribo electrostatic charging to enhance magnetic susceptibility. Preliminary tests have shown that following grinding to 5 micron, ash reduction from 6-8 percent to 3 percent can be achieved. Grinding carried out in air attrition mill (Alpine). Al will send details.

2. EPRI

An extension is being planned to the existing facility at Homer City for a 1 t/h pilot section to study selective deep cleaning processes.

Contact: Clark Harrison
EPRI
P. O. Box 98
Homer City, PA 15748

3. UNIVERSITY OF IOWA

Suggested a call to Dave Birlingmair, (515) 294-3758, directly, for recent pilot plant program at the Ames Plant.

4. UNIVERSITY OF SOUTHERN ILLINOIS, CARBONDALE

No pilot plant testing, only bench scale.

5. BATTELLE

Some froth flotation testing at bench scale.

.../2

6. CONSOL

Pilot plant testing of deep cleaning processes have been carried out, although little has been published.

Suggested writing to:

James Clancey
Director - Engineering
Coal Research Division
Conoco Inc.
4000 Brownsville Road
Library, PA 15129

ADW/mr

## 4.2 COAL CLEANING TEST FACILITY, ELECTRIC POWER RESEARCH INSTITUTE (EPRI), HOMER CITY, PENNSYLVANIA

# COAL CLEANING TEST FACILITY
# ELECTRIC POWER RESEARCH INSTITUTE (EPRI)
# HOMER CITY, PENNSYLVANIA

The existing 25 tonnes per hour pilot plant consists of a heavy medium cyclone section, water-only cyclone and froth flotation. (Details are given in the attached description of the facility.)

Research into deep cleaning has been carried out in a program on multistage froth flotation.

EPRI plans to install a one-tonne per hour pilot plant using micro-bubble flotation. Development work on this project has been carried out by Bechtel, Inc.

Plans are also being made to install a one-tonne per hour pilot plant for research into electrostatic separation based on preliminary research work carried out by Advanced Energy Dynamics. Both the above projects aim to produce a clean coal of 2.0 percent ash at 80.0 percent BTW recovery.

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 25, 1985

Mr. Clark Harrison
Electric Power Research Institute
P.O. Box 98
Homer City
PA 15748
U.S.A.

Dear Mr. Harrison:

Kilborn Engineering have recently been awarded a contract by the Canadian Department of Energy, Mines and Resources for the development and design of a pilot plant for the study of continuous operations of 'deep cleaning' processes for coal. The plant will be an extension of the existing pilot plant at Edmonton and will likely consist of a fine grinding section followed by such process options as froth flotation, oil agglomeration, high density magnetic separation, etc. The initial phase of the project will be a review of 'deep cleaning' process and existing pilot plant installations.

I am writing to you to request current information on the EPRI pilot plant and on any future plans for the addition of 'deep cleaning' processes.

If you are able to provide assistance in this area, we would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B.C.) LTD.

A.D. Walters

A.D. Walters
Manager - Coal Preparation

ADW/rlk

**U.S. DEPARTMENT OF ENERGY**
**PITTSBURGH ENERGY TECHNOLOGY CENTER**
**OFFICE OF PUBLIC INFORMATION**
**P.O. BOX 10940**
**PITTSBURGH, PA 15236**

**DOENEWS:**

RECEIVED
SEP 0 3 1985
EPRI TEST FACILITY

News Media Contact:
Robert C. Porter, 202/252-6503
Kay Downey, 412/675-6128

FOR IMMEDIATE RELEASE
August 30, 1985

# ENERGY DEPARTMENT TO START "SUPERCLEAN" COAL PROJECTS

"Supercleaning" coal -- that is, removing sulfur and other impurities locked too tightly in coal's structure to be reached by conventional coal cleaning methods -- will be the focus of seven research projects selected by the Energy Department for federal funding.

The department has opened contract negotiations with:

- o Advanced Energy Dynamics, Natick, Massachusetts
- o Bechtel National, Inc., San Francisco, California
- o Michigan Technological University, Houghton, Michigan
- o Norton, Hambleton Inc., Ann Arbor, Michigan
- o Atlantic Research Corporation, Alexandria, Virginia (2 projects)
- o Institute of Gas Technology, Chicago, Illinois

Energy Secretary John S. Herrington said that the Energy Department expects to provide more than $6 million in federal funds to be shared by the six firms selected from two separate solicitations. The exact amount for each firm will depend on the outcome of the contract talks expected to be concluded during September.

"Although nearly one third of all coal sent to steam boilers today is washed or cleaned in some fashion, there is significant room for technological improvement," Herrington said. "This effort will attempt to identify new concepts that go significantly beyond today's state-of-the-art technology. We hope to establish the technology that could someday produce a 'superclean' coal that would require little, if any, additional environmental clean-up."

(MORE)

Two of the firms, Advanced Energy Dynamics and Bechtel, will test their concepts at the Electric Power Research Institute's (EPRI) Coal Cleaning Test Facility near Homer City, Penn. Last year, the department and EPRI agreed to cooperate in joint tests to remove the ash and iron-bound or "pyritic" sulfur from coal.

Advanced Energy Dynamics will use a dry electrostatic process to clean finely-ground coal. Bechtel will test a process that "floats" fine particles of coal to the surface of a water-filled cell using "microbubbles" leaving behind the impurities. The two firms will divide about $3.5 million this year and will install and test the concepts at EPRI's facility during the next two and one-half years.

From a separate solicitation, the department has selected five other coal cleaning concepts to be examined at smaller scales compared to the EPRI facility tests.

Three of the proposals involve advanced technologies to remove pyritic sulfur. Michigan Technological University will study a "static tube flotation" system. Norton, Hambleton Inc. will attempt to remove impurities from crushed coal by treating it with an organic liquid and spinning the coal particles in a cyclone separator. Atlantic Research will study a method of using microbes to augment a technique for separating ash and pyritic sulfur from coal.

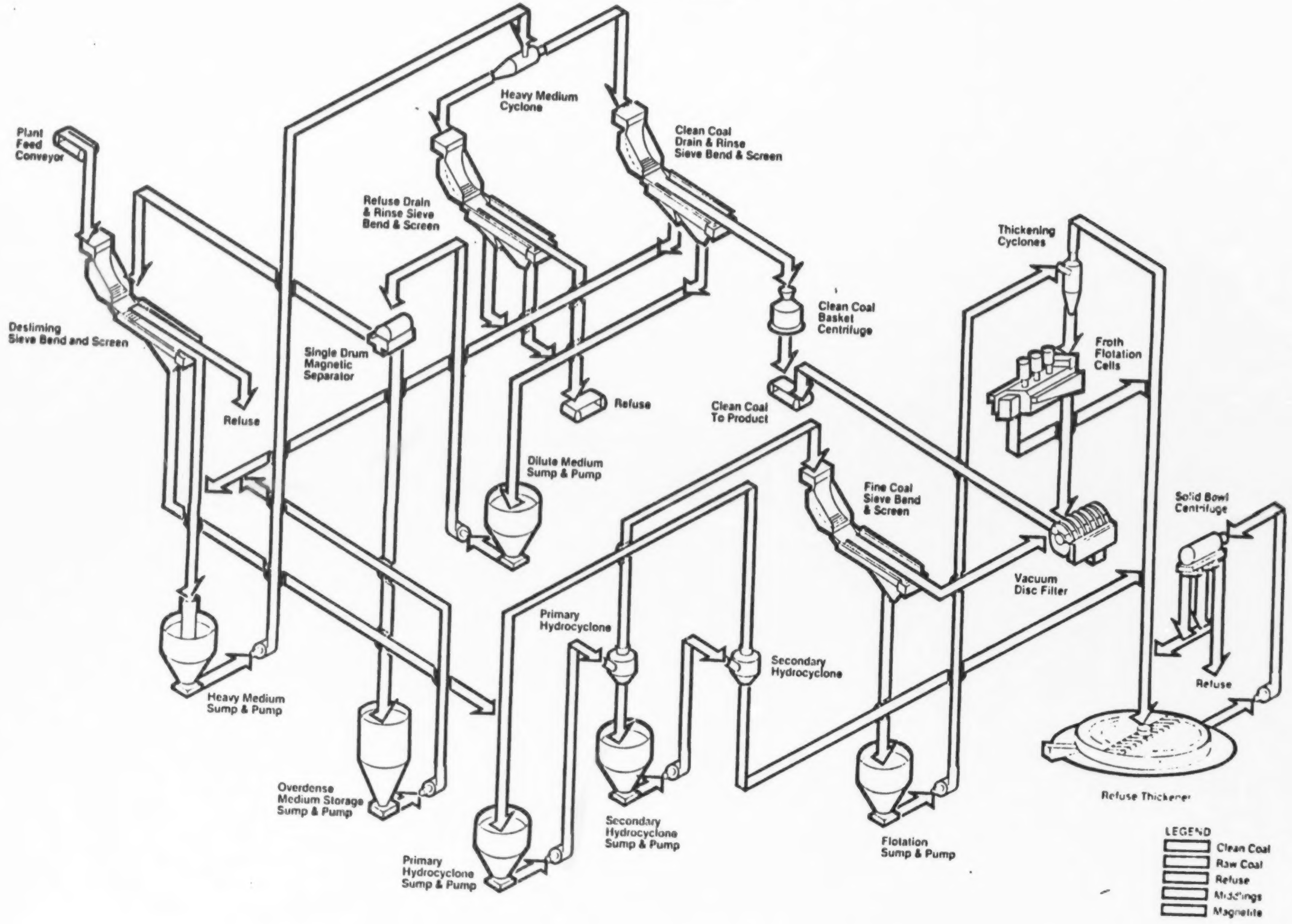
Two proposals have been selected to examine techniques for using microorganisms to consume organic sulfur in coal. Organic sulfur, as contrasted to pyritic sulfur, is chemically bound to the coal itself and is much more difficult to separate. Both the Institute of Gas Technology and Atlantic Research will study this approach to coal cleaning.

The department's Pittsburgh Energy Technology Center conducted the competition and will manage the projects following contract awards.

-DOE/PETC-

NOTE: This is a simultaneous release with the Department of Energy Headquarters in Washington, D.C.

# EPRI CTF
## Flowsheet No. 1


Plant Feed Conveyor
Desliming Sieve Bend and Screen
Refuse
Heavy Medium Sump & Pump
Overdense Medium Storage Sump & Pump
Single Drum Magnetic Separator
Refuse Drain & Rinse Sieve Bend & Screen
Heavy Medium Cyclone
Clean Coal Drain & Rinse Sieve Bend & Screen
Refuse
Dilute Medium Sump & Pump
Clean Coal Basket Centrifuge
Clean Coal To Product
Primary Hydrocyclone
Primary Hydrocyclone Sump & Pump
Secondary Hydrocyclone
Secondary Hydrocyclone Sump & Pump
Fine Coal Sieve Bend & Screen
Flotation Sump & Pump
Vacuum Disc Filter
Thickening Cyclones
Froth Flotation Cells
Solid Bowl Centrifuge
Refuse
Refuse Thickener
LEGEND
Clean Coal
Raw Coal
Refuse
Middlings
Magnetite

# EPRI CCTF
## Flowsheet No. 2

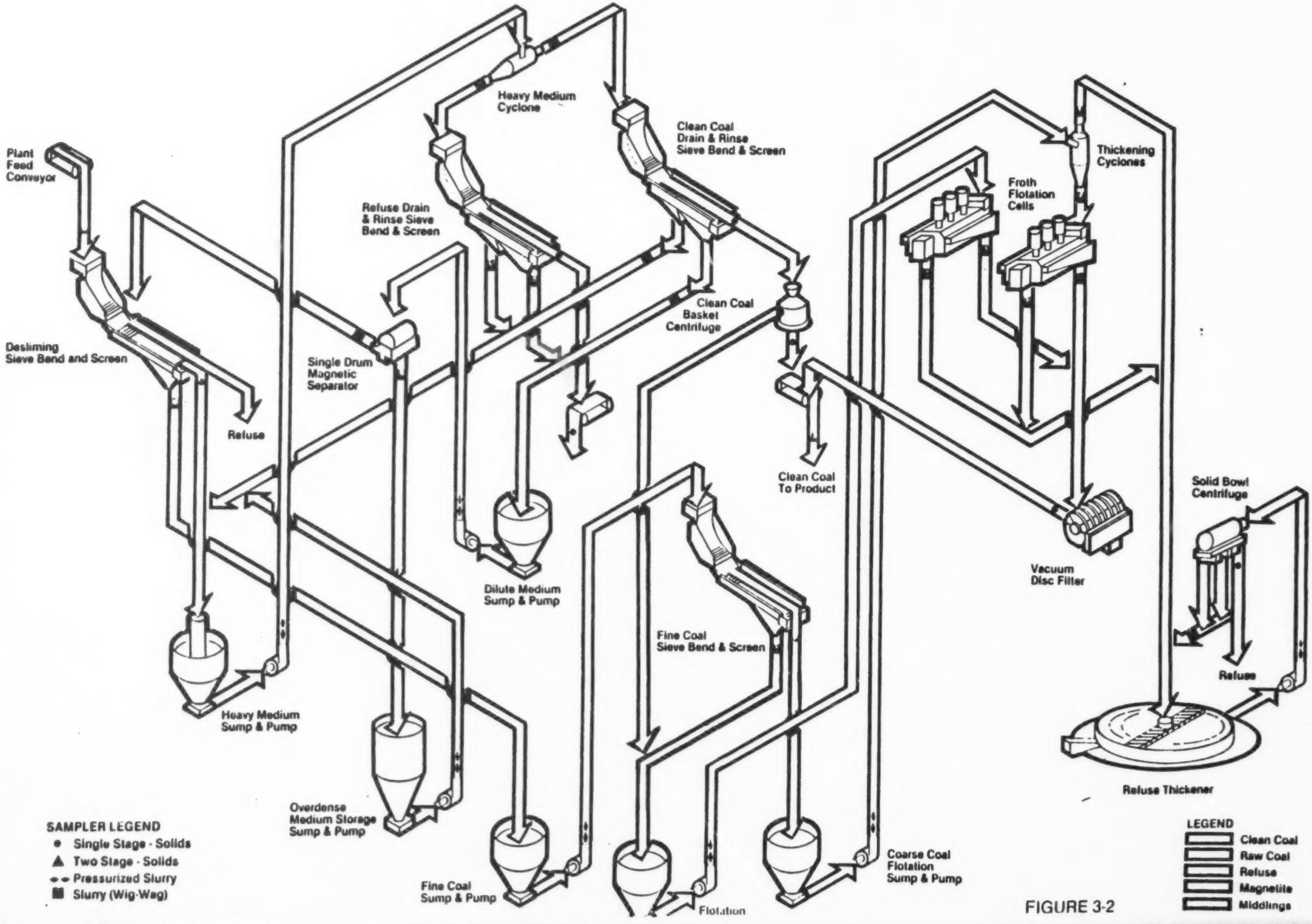
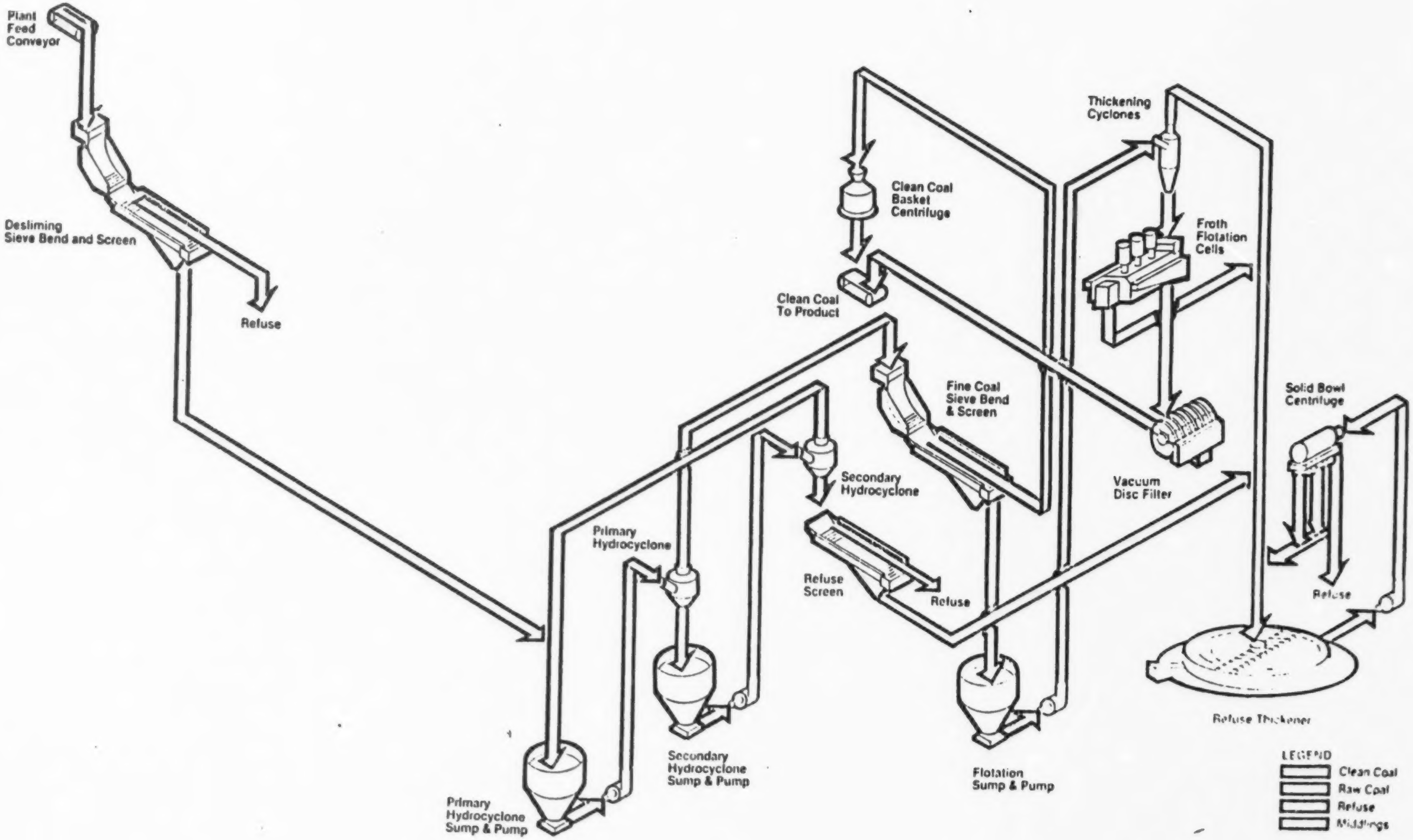

Plant Feed Conveyor
Desliming Sieve Bend and Screen
Refuse
Heavy Medium Cyclone
Refuse Drain & Rinse Sieve Bend & Screen
Single Drum Magnetic Separator
Clean Coal Drain & Rinse Sieve Bend & Screen
Clean Coal Basket Centrifuge
Clean Coal To Product
Thickening Cyclones
Froth Flotation Cells
Vacuum Disc Filter
Solid Bowl Centrifuge
Refuse
Refuse Thickener
Heavy Medium Sump & Pump
Dilute Medium Sump & Pump
Overdense Medium Storage Sump & Pump
Fine Coal Sieve Bend & Screen
Fine Coal Sump & Pump
Flotation
Coarse Coal Flotation Sump & Pump
SAMPLER LEGEND
● Single Stage - Solids
▲ Two Stage - Solids
◆◆ Pressurized Slurry
■ Slurry (Wig-Wag)
LEGEND
Clean Coal
Raw Coal
Refuse
Magnetite
Middlings

FIGURE 3-2

EPRI CTF

# Flowsheet No. 3


Plant Feed Conveyor
Desliming Sieve Bend and Screen
Refuse
Clean Coal Basket Centrifuge
Clean Coal To Product
Thickening Cyclones
Froth Flotation Cells
Fine Coal Sieve Bend & Screen
Solid Bowl Centrifuge
Secondary Hydrocyclone
Vacuum Disc Filter
Primary Hydrocyclone
Refuse Screen
Refuse
Refuse
Refuse Thickener
Secondary Hydrocyclone Sump & Pump
Flotation Sump & Pump
Primary Hydrocyclone Sump & Pump
LEGEND
Clean Coal
Raw Coal
Refuse
Middlings

# EPRI CCTF
## Flowsheet No. 4

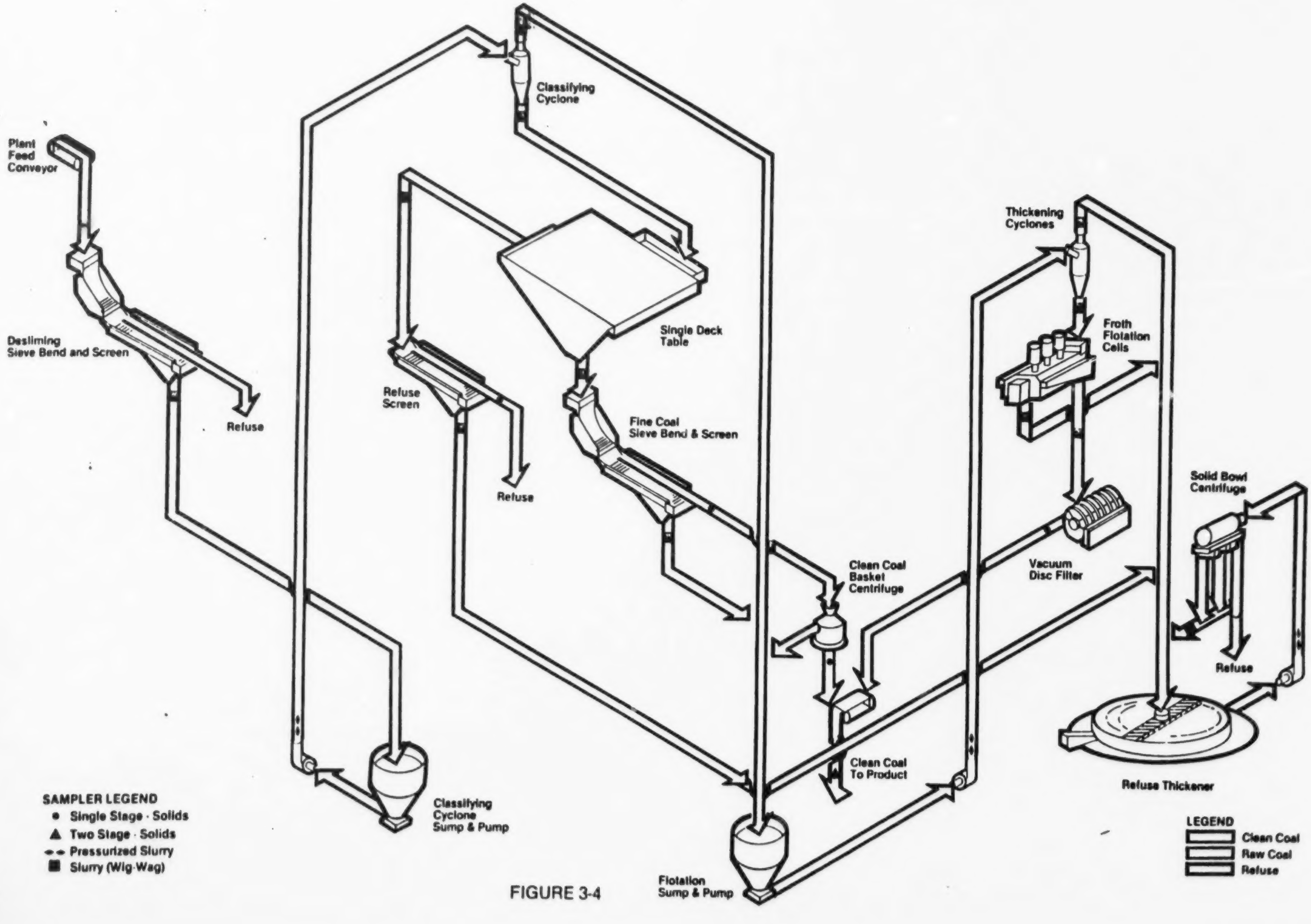

Plant Feed Conveyor
Desliming Sieve Bend and Screen
Refuse
Classifying Cyclone
Refuse Screen
Refuse
Single Deck Table
Fine Coal Sieve Bend & Screen
Clean Coal Basket Centrifuge
Clean Coal To Product
Thickening Cyclones
Froth Flotation Cells
Vacuum Disc Filter
Solid Bowl Centrifuge
Refuse
Refuse Thickener
Classifying Cyclone Sump & Pump
Flotation Sump & Pump
SAMPLER LEGEND
● Single Stage · Solids
▲ Two Stage · Solids
◆◆ Pressurized Slurry
■ Slurry (Wig-Wag)
LEGEND
Clean Coal
Raw Coal
Refuse

FIGURE 3-4

# EPRI CCTF
## Flowsheet No. 5

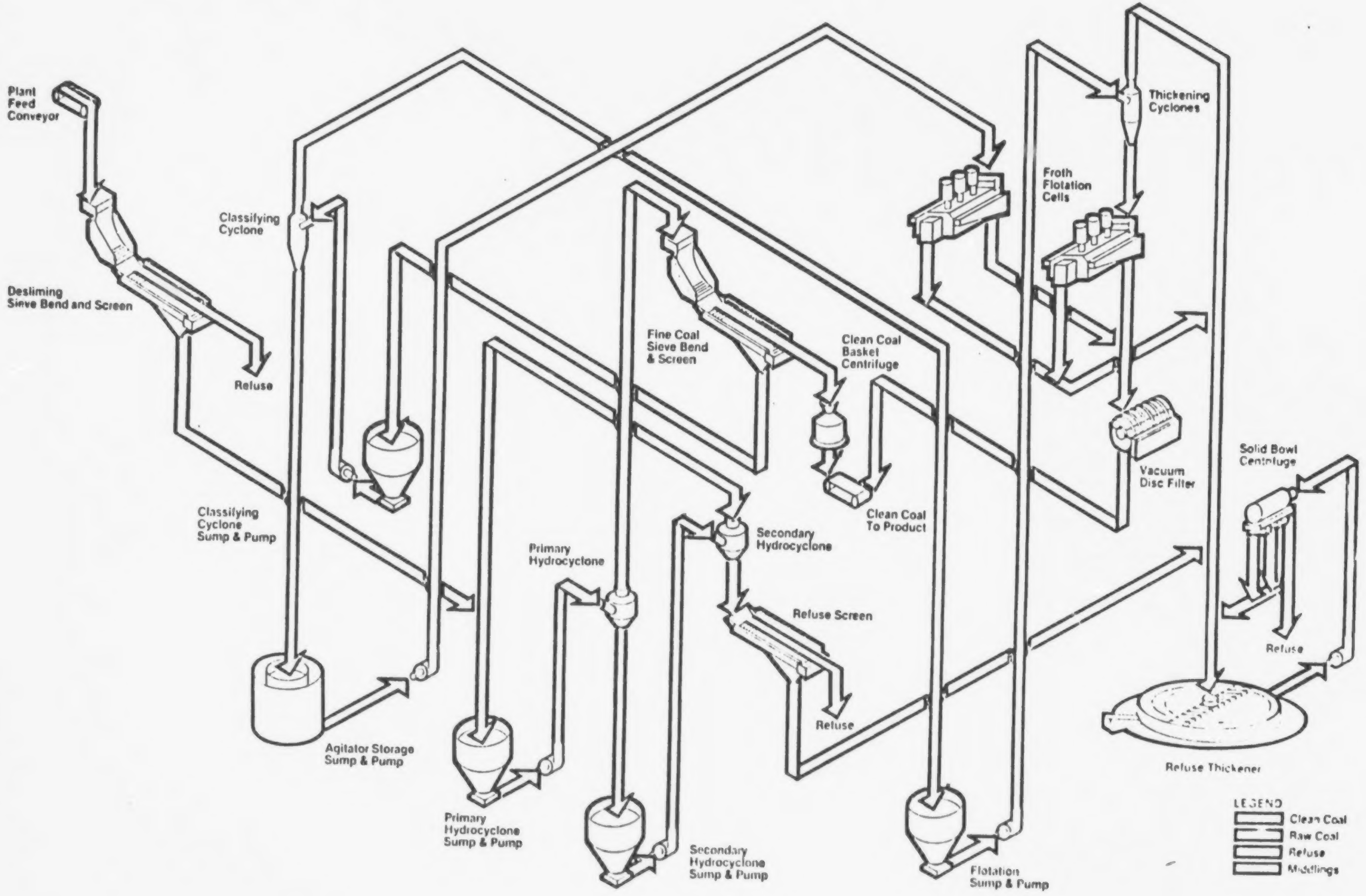
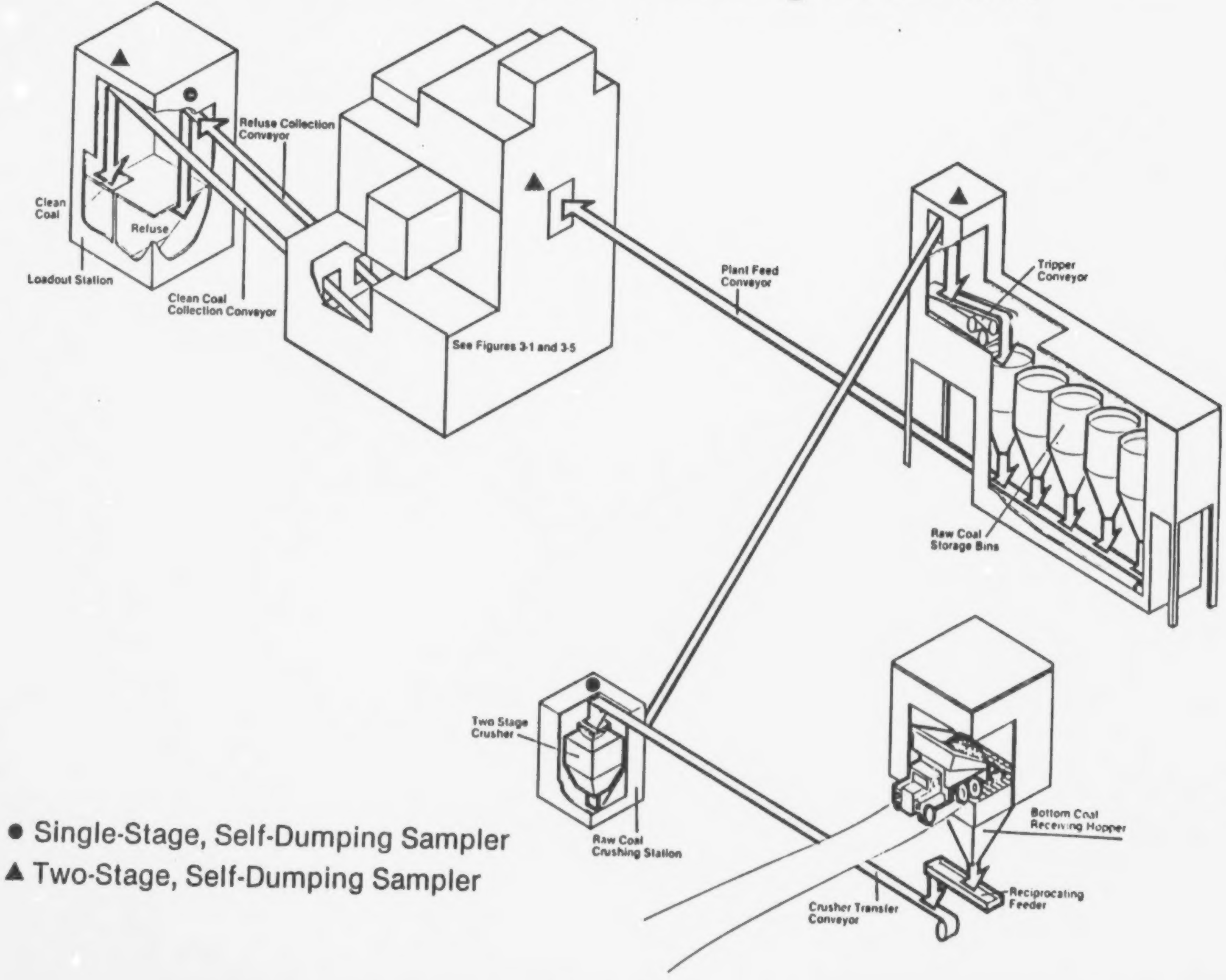

Plant Feed Conveyor
Desliming Sieve Bend and Screen
Refuse
Classifying Cyclone
Classifying Cyclone Sump & Pump
Agitator Storage Sump & Pump
Primary Hydrocyclone
Primary Hydrocyclone Sump & Pump
Fine Coal Sieve Bend & Screen
Secondary Hydrocyclone
Secondary Hydrocyclone Sump & Pump
Refuse Screen
Refuse
Clean Coal Basket Centrifuge
Clean Coal To Product
Froth Flotation Cells
Thickening Cyclones
Vacuum Disc Filter
Flotation Sump & Pump
Solid Bowl Centrifuge
Refuse
Refuse Thickener
LEGEND
Clean Coal
Raw Coal
Refuse
Middlings

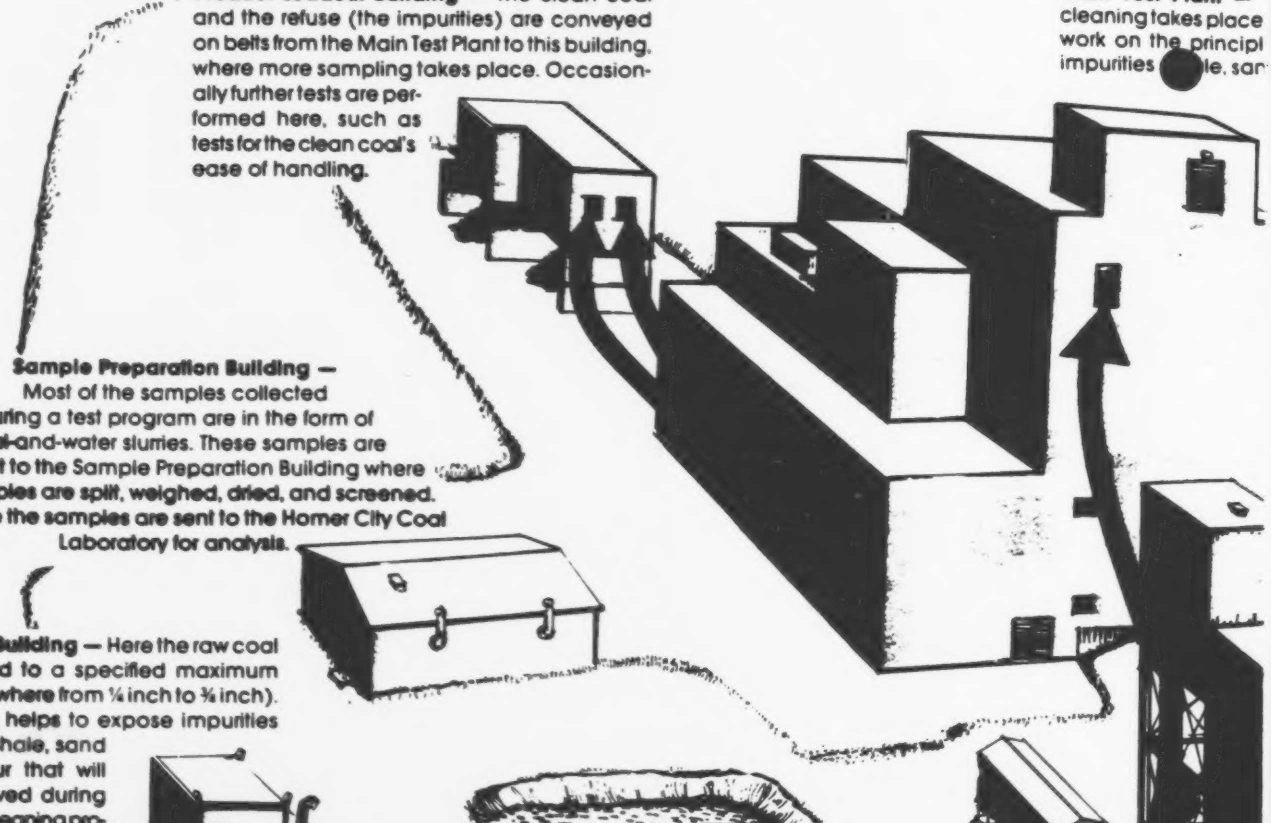
Figure 3-6

## Bulk Sampling Stations Outside the Coal Cleaning Test Plant


Refuse Collection Conveyor
Clean Coal
Refuse
Loadout Station
Clean Coal Collection Conveyor
See Figures 3-1 and 3-5
Plant Feed Conveyor
Tripper Conveyor
Raw Coal Storage Bins
Two Stage Crusher
Raw Coal Crushing Station
Bottom Coal Receiving Hopper
Reciprocating Feeder
Crusher Transfer Conveyor
● Single-Stage, Self-Dumping Sampler
▲ Two-Stage, Self-Dumping Sampler

EPRI
CCTF
COAL CLEANING TEST FACILITY

# Plant Guide



**Product Loadout Building** — The clean coal and the refuse (the impurities) are conveyed on belts from the Main Test Plant to this building, where more sampling takes place. Occasionally further tests are performed here, such as tests for the clean coal's ease of handling.

**Main Test Plant** —
cleaning takes place
work on the principl
impurities ●le, sar

**Sample Preparation Building** — Most of the samples collected during a test program are in the form of coal-and-water slurries. These samples are brought to the Sample Preparation Building where the samples are split, weighed, dried, and screened. From here the samples are sent to the Homer City Coal Laboratory for analysis.

**Crusher Building** — Here the raw coal is crushed to a specified maximum size (anywhere from ¼ inch to ¾ inch). Crushing helps to expose impurities such as shale, sand and sulfur that will be removed during the coal cleaning process. Here, too, the coal is first sampled to determine its quality and characteristics.

**Receiving Station** — The raw (or uncleaned) coal is delivered here by truck or by railcar. The coal is placed in a 30-ton receiving hopper covered by a steel grid that screens off pieces larger than 6 inches—a size large enough to damage the plant's equipment. Instruments at this station control the raw coal's path from here, through the Crusher Building, and into the Bin Building where the raw coal is stored before cleaning.

**Bin Buildi**
— From t
Crusher
ing, the r
travels b
belt to th
Bin Buildi
fed into c
bins for st
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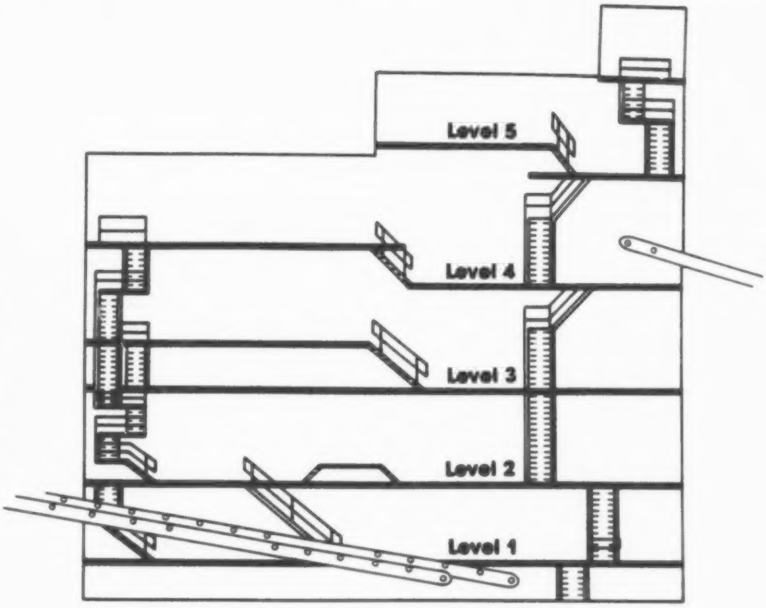
begin, w
tom of th
as it flows
carries it

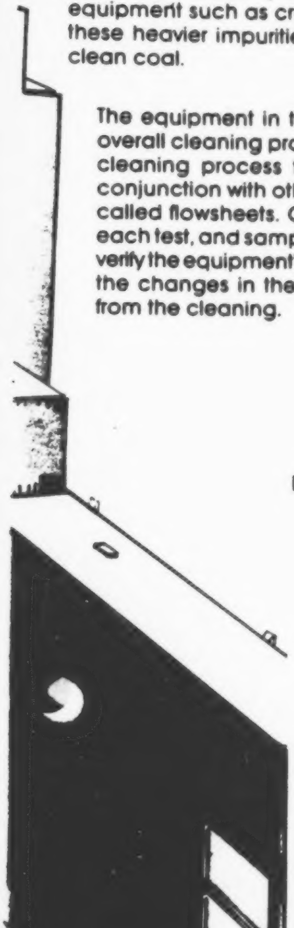
This Plant Guide is a publication of the Electric Power Research Institute's Coal Cleaning Test Facility.
Level drawings by Ray Callihan.

· This is where the actual coal e. Most coal cleaning processes ple that coal is lighter than the nd d sulfur) that attach themselves to the coal either externally or dispersed within he coal. Liquids (usually just plain water) and equipment such as crushers and screens separate these heavier impurities from the coal to produce clean coal.

The equipment in the test plant is not part of one overall cleaning process; rather, each is a separate cleaning process that can be used alone or in conjunction with other equipment in configurations called flowsheets. Computers control and monitor each test, and samples are taken during each test to verify the equipment's performance and to determine the changes in the coal's characteristics resulting from the cleaning.



**Begin the tour of the Main Test Plant on Level 5.**



ding
the
r Build-
raw coal
by conveyor
he top of the
ding, where it is
one of five 100-ton
storage. When tests
particular coal are to
weighfeeders at the bot-
the bins meter the raw coal
ws onto a conveyor belt that
it into the Main Test Plant.

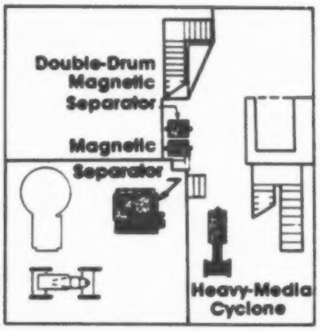
**Path of coal through the facility.**

### Level 5

A **heavy-media cyclone** cleans raw coal by swirling it with water. Impurities (such as shale, sand, and sulfur) are denser than coal and so sink to the bottom. The clean coal floats out the top.

Because iron ore is magnetic and therefore easy to recover, it is added to the water to increase density, making the cleaning process more efficient.

A **magnetic separator** with scraper then recovers the iron ore (magnetite) so that it can be continuously reused. To speed this process, commercial coal-cleaning plants frequently use **double-drum magnetic separators.**



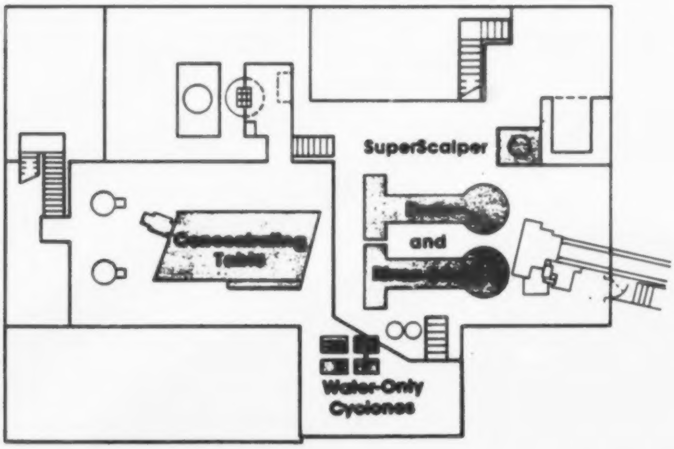
### Level 4

The clean coal and refuse exiting the heavy-media cyclone go to **drain and rinse screens** where they are sprayed to remove the magnetite. The resulting magnetite slurry goes to the magnetic separators on Level 5, while the clean coal and refuse continue on to machines that remove excess water.

Three other cleaning devices are located on Level 4. One of these, called a **SuperScalper,** uses an upward spiral of water to separate coal from its impurities. The denser impurities fall to the bottom and the coal, which is lighter, flows with the water out the top of the tank.

A **water-only cyclone** is similar to a heavy-media cyclone except that it does not use magnetite and so is not quite as efficient.

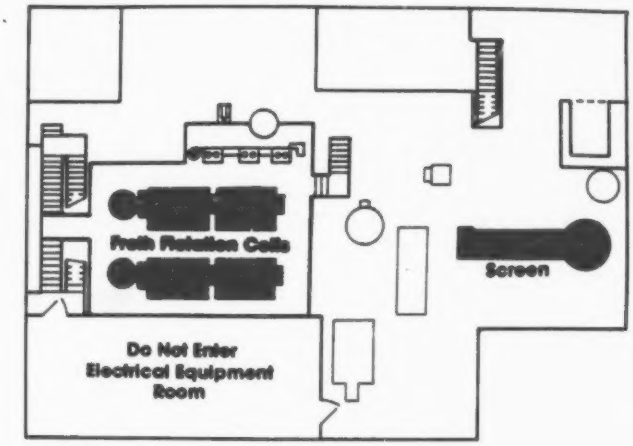
The **concentrating table** is patterned after the method for panning gold common in pioneer days. Heavier refuse is trapped behind the ribs while clean coal (again lighter than refuse) bounces over the ribs and washes off the front of the table.



### Level 3

Because each cleaning device is more efficient for a specific size of coal, the raw coal entering the test plant is conveyed first to a **vibrating screen** that separates the coal into various sizes. Once separated, the coal is ready to be cleaned.

A **froth flotation cell** is the only coal-cleaning device that does not depend on gravity to separate impurities from raw coal. A tank above the cells mixes pine oil or alcohol with fine coal particles to form a froth that is fed into the froth flotation cells. Agitators in the cells stir the mixture and create air bubbles. Because coal repels water, it attaches to the bubbles and rises to the surface where it is removed by rotating paddles. Impurities (sand, sulfur, shale) act like sponges and absorb water, causing them to sink to the bottom.

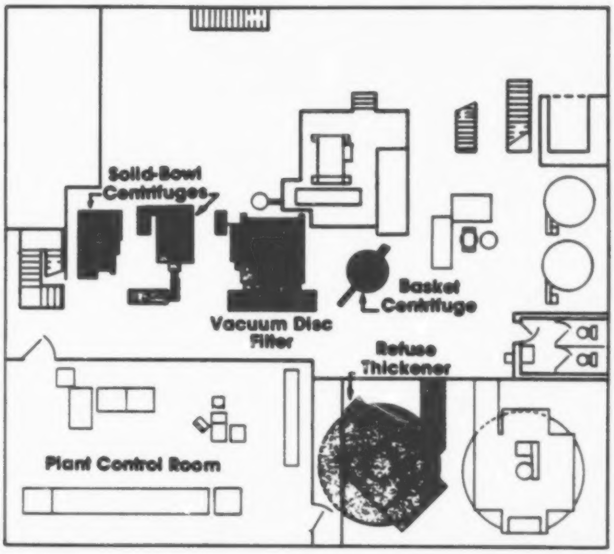


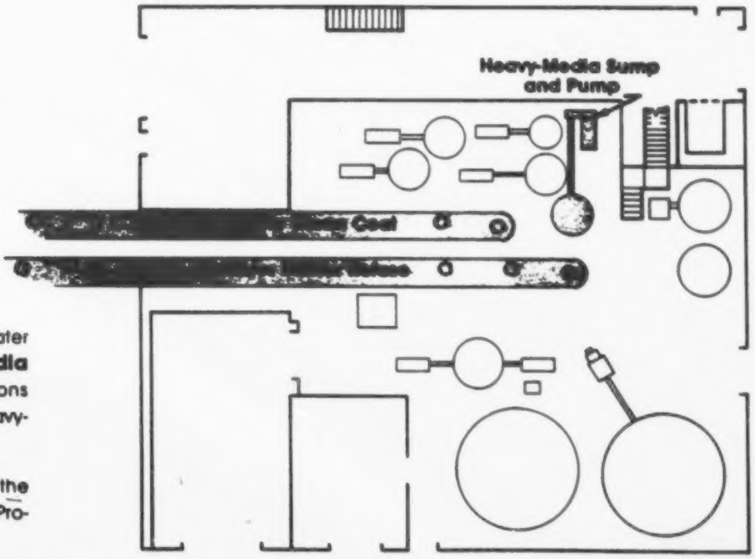
### Level 2

A **refuse thickener** located just outside the plant control room clarifies the waste water from the various coal-cleaning devices so that the water can be used again.

Because very fine particles settle slowly, chemicals called flocculants are added, causing the fine particles to cling together and settle more quickly into a sludge at the bottom of the thickener. This sludge is then pumped to a **solid-bowl centrifuge** that spins the sludge at high speeds, causing the solids and moisture to separate. The refuse solids, which form a cake on the centrifuge walls, are continuously removed while the waste water flows out a pipe.

A **basket centrifuge** (similar to a clothes dryer without heat) removes water from the clean coal and refuse produced by the various coal-cleaning devices. A **vacuum disc filter** removes water from clean coal and refuse that is finer than sand.





### Level 1

Various sumps and pumps are necessary for mixing water with the coal particles to be cleaned. The **heavy-media sump and pump,** for example, supply 300 to 400 gallons of water per minute to transport raw coal to the heavy-media cyclone.

**Conveyor belts** carry the clean coal and refuse from the various cleaning devices in the Main Test Plant to the Product Loadout Building.

# COAL CLEANING TEST FACILITY

The Coal Cleaning Test Facility was established by the Electric Power Research Institute—the research arm of the U.S. electric utility industry—to advance coal-cleaning technology and investigate its potential for reducing the cost of generating electricity.

The CCTF, which is a commercial-scale facility for cleaning coal and for removing moisture from the cleaned coal, is a proving ground for coal-cleaning strategies and for developing and demonstrating new coal-cleaning equipment.

| | |
|---|---|
| **Cost** | $15 million |
| **Annual Operating Budget** | $3.5 million |
| **Number of Employees** | 30 |
| **Plant Capacity** | 25 tons an hour |
| **Construction History** | Construction began in October 1979; limited testing occurred in July 1981; full operation was achieved in September 1981. |
| **Value** | Improved coal-cleaning technology can lead to reduced air pollution and increased power plant efficiency. |

# CLEANING PROCESS

The coal is separated into various sizes (between 6 inches and the fineness of talcum powder) and mixed with water. This slurry mixture is then fed into different machines—depending on the cleaning process to be used—where the coal is separated from impurities such as slate, shale and sulfur. After the coal is cleaned and the water removed, the coal particles are recombined and carried by conveyor belt to storage areas. The water is also removed from refuse products, which are then transported by conveyor belt out of the plant for disposal.

During the cleaning process, the water is treated and reused continuously.

The equipment to be used and the feed rate required for each process are determined by the characteristics of the raw coal and the specifications the clean coal must meet.

## EPRI

Electric Power Research Institute
Post Office Box 10412, Palo Alto, CA 94303
415-855-2000

EPRI is the non-profit research and development arm of the electric power industry. With funds contributed by its nearly 500 members, EPRI manages a wide-ranging research program into all aspects of electric power production, distribution, and use.

## CCTF

Coal Cleaning Test Facility
Post Office Box 98
Homer City, PA 15748
412-479-3503

The CCTF is sponsored by the Electric Power Research Institute (EPRI); Pennsylvania Electric Company (Penelec); New York State Electric & Gas Corporation (NYSEG); and Empire State Electric Energy Research Corporation (ESEERCO). It is staffed by EPRI; Raymond Kaiser Engineers, Inc.; and Science Applications International Corporation.

The Homer City Coal Laboratory, managed by Penelec, analyzes CCTF test samples.

For further information contact
Clark Harrison, Manager,
Coal Cleaning Test Facility
412-479-3503 or 412-856-7120.

## 4.3 COAL PREPARATION RESEARCH FACILITIES, IOWA STATE UNIVERSITY, AMES

# KILBORN ENGINEERING (B.C.) LTD.

## INTER - OFFICE MEMORANDUM

FROM A. D. WALTERS    TO RECORD
DATE NOVEMBER 22, 1985    COPY TO
SUBJECT DEEP CLEANING    COPY TO
FILE No. 7813-15    COPY TO

PHONE CALL: Dave Birlingmair
Head, Coal Preparation
321 Spedding Hall
Ames Laboratory
Iowa State University
Ames, Iowa 50011

Telephone: (515) 294-3758

Requested additional information to their published Fact Sheet. He will send a selection of reports to Kilborn, although he has very little other published data on the plant itself. The heavy medium circuit has 3 cyclones: 20 inches, 14 inches and 8 inches.

The deep cleaning section is batch rather than continuous, the ball mill is a Denver 14-inch dia by 6 feet length. Ball mill feed is either minus 0.5 mm natural arisings or total coal pre-crushed in a Hammer mill. The high gradient magnetic separation equipment was never installed, although specs. were prepared and Sala equipment selected. The chemcial desulphurization has never been installed, although a one litre autoclave has been purchased from Autoclave Engineering Inc.

ADW/mr

AL 3-84

# IOWA STATE UNIVERSITY

# AMES LABORATORY

# COAL PREPARATION RESEARCH FACILITIES

# FACT SHEET

## I. PLANT EQUIPMENT AND CAPABILITIES - CONTINUOUS PROCESS CIRCUITS

### A. Receiving and Sizing Equipment

1. Up to 1,500 tons of feedstock can be held in a paved storage area for processing.
2. A 100 ton per hour impact mill will crush run-of-mine coal from three-inch top size to 1/8-inch top size.
3. Surge hopper and weigh feeder system provide plant feeds from 5 to 80 tons per hour.

### B. Heavy Media Vessel

1. Equipment includes a cone shaped vessel, drain and rinse screens, media recovery and control systems.
2. Capacity is 10 to 50 tons per hour of three-inch x 3/8-inch coal.
3. Specific gravity of separation from 1.25 to 1.70 can be accomplished.

### C. Heavy Media Cyclone Circuit

1. Equipment includes a heavy media cyclone, drain and rinse screens, magnetic separators, and density controls.
2. Capacity ranges from a few hundred pounds up to 25 tons per hour of 3/8" x 28 mesh coal with the option of 1" x 28 mesh.
3. Circuit is designed to operate with on-line monitoring and process control equipment.
4. Separations in this size range are possible at specific gravities from 1.3 to 1.8 range.

### D. Concentration Table Circuit

1. Equipment includes double deck concentration table, sieve bend, and dewatering screen.
2. Capacity is 5 to 35 tons per hour with 3/8 x 0 feed. Minus 28 mesh material passes through circuit with screen underflow.

### E. Hydrocyclone and Filtration Circuit

1. Circuit includes hydrocyclones, dewatering cyclones, disc filters, and an advanced design thickener.
2. Circuit will beneficiate and dewater the entire -28 mesh output from existing plant.
3. Circuit is set up to do fine coal beneficiation research work with hydrocyclones on fine coal.

## II. BATCH PROCESS EQUIPMENT CIRCUITS

### A. Fine Coal Beneficiation Circuits

#### 1. Pretreatment Circuit

- a. Facilities for storage, fines pulverization, classification, heating, and chemical pretreatment of coal/water slurry.
- b. Preparation of feedstock for oil agglomeration, froth flotation, briquetting, and pelletization.
- c. Processing rate: 100 to 500 lb./hr.

#### 2. Oil Agglomeration Circuit

- a. Two-stage oil agglomeration circuit containing:
    - (1) Preheated oil for emulsifier.
    - (2) High shear emulsifier.
    - (3) Two agglomeration tanks with variable speed mixers and heating capability.
    - (4) Two orbital screens for separation from mineral matter.
- b. Processing rate: 100 lb./hr.

#### 3. Froth Flotation Circuit

- a. Four-cell unit (5 cubic feet per cell).
- b. Reagent feeders.
- c. Discharge pumps.
- d. Processing rate: 300-500 lb./hr.

#### 4. Chemical Desulfurization Circuit

- a. Two one-liter and one 300-ml stirred pressure vessels.
- b. Elevated temperature capability.
- c. Processing rate: up to 150 gm/hr.

#### 5. Recirculating Heavy Media Cyclone Circuit

- a. Eight-inch heavy media cyclone.
- b. Density sensing and recording.
- c. Full stream sample splitter.
- d. Sump capacity: 150 gallons
- e. Processing rate: 100-200 lb/min.

B. Fine Coal Size Reconstitution Circuits

1. Disc Pelletizer Circuit

   a. Thirty-six-inch diameter disc.
   b. Fourteen-inch diameter insert.
   c. Heated binder feed system.
   d. Processing rate: 200-500 lb/hr.

2. Roll Briquetting Circuit

   a. Five-inch diameter rolls.
   b. Two sets pocket rolls, one set smooth rolls.
   c. Feed blending mixer.
   d. Processing rate: 10-50 lb/hr.

3. Pellet Mill Circuit

   a. Six-inch die with 1/2-inch diameter holes.
   b. Volumetric feed system.
   c. Processing rate: 50-60 lb/hr.

C. Combustion Testing equipment

1. Air Flow and Combustion Measuring System

   a. Temperature and flow monitors.
   b. CO, $CO_2$, $O_2$ monitors.
   c. Stack gas and particulate sample trains.

2. Combustors

   a. Tuyere type stoker fired.
   b. Combustion rate: 30-60 lb/hr.

III. PLANT OPERATION

A. Personnel - Operating employees with three to five years experience operate the processing equipment with a Mechanical Engineer in charge.

B. Schedule - During production the plant is operated approximately six hours per day, four days per week, with maintenance and cleanup on the fifth day. Start-up ordinarily takes from 15 to 20 minutes, with steady state operation achieved in less than 30 minutes. Experimental work and batch processing is scheduled five days per week.

C. Production - Output ranges from 3,000 to 6,500 tons per month, depending on the number of tests performed and extent of variations during tests.

## IV. EQUIPMENT AND SUPPORT FACILITIES

### A. Coal Processing Equipment

Heavy Media Separator (cone)
Heavy Media Cyclones (20-inch, 14-inch, and 8-inch)
Concentration Tables
Hydrocyclones
Separating Screens
Dewatering Screens
Sieve Bends
Conveying Equipment
Settling Basin with Flocculation Equipment
Crusher
Hopper and Vibratory Feeder
Electronic Weigh Scale
Media Density Monitoring and Control System
Dewatering Cyclones
Disc Filters (coal and refuse)
Water Clarifier
Pumps and Process Control Systems
Washability and Sample Preparation Laboratory
Building and Grounds with Complete Utilities Support
Concrete storage areas for raw coal, clean coal and refuse
Coal Slurry Preconditioning Circuit
    Mixing Tanks with Heat/Cool Capability
    Ball Mill
    Cyclone Classifiers
    Chemical and Oxygen Injection
Froth Flotation Equipment
Oil Agglomeration Circuit
Attrition Mill
Disc Pelletizer
Pellet Mill
Briquetting Circuit
Recirculating Eight-Inch Heavy Media Cyclone Test Circuit

### B. Existing Support Facilities

Rail Siding Serving Iowa State Univerity Power Plant is Available to Serve Coal Preparation Facility
    One Half Mile Trackage
    Car Unloading Equipment with Undertrack Hoppers
    Crusher
    Conveying Equipment

## V. ADDITIONAL FACTS

### A. Processing Rates

Full-Scale Coal Preparation Research Plant - 20 to 70 TPH.
Fine Coal Hydrocyclone Circuit - 3 to 7 TPH.
Advanced Fine Coal Circuitry - 100 to 300 lbs./hr.

B. Coals Processed to Date Through Plant (more than 100,000 tons total)

Thirteen 1,000-ton beneficiation tests of various Iowa coals.
Approximately 48,000 tons of coal from ISU Demonstration Mine #1.
40,000 tons steam coal cleaned to support the Iowa coal industry.
400 tons Wyoming coal.
200 tons West Virginia coal.
Two 1,500 ton quantities for particulate emission tests.
60, 90, and 100-ton quantities of coal from Pittsburgh, Illinois No. 6, and Upper Freeport seams prepared for fine coal combustion research.

C. Emphasis of Research

Evaluations of coal beneficiation processes and techniques on semi-commercial scale.

Fine coal beneficiation and sulfur reduction process development using advanced mechanical, physical, chemical, and magnetic separation techniques.

Preparation of large quantities of specially processed coals for combustion tests or as feedstocks.

D. Plant Availability

Plant is available and suitable for both batch and full-scale preparation evaluations on any U. S. coal, as well as for installation of any new processing or control equipment technology being developed at Ames Laboratory or elsewhere.

Plant maintains a balanced water circuit, and refuse is disposed of in an approved city landfill.

E. The Iowa State University Power plant has a steaming capacity of 750,000 lbs./hr. with an electrical capacity of 36.5 Mw. The plant can be used for large scale combustion tests and emission measurements.

The boilers are: one coal-fired, chain grate; three coal, gas or combination fired, chain grate; two coal, gas or combination fired, spreader stoker with any of the latter capable of accepting oil burners.

Coal with heating values between 9,000 Btu/lb. and 13,000 Btu/lb. and ash content between 5% and 20% can be utilized with no operational problems.

---

For further details regarding the Coal Preparation Plant, contact:

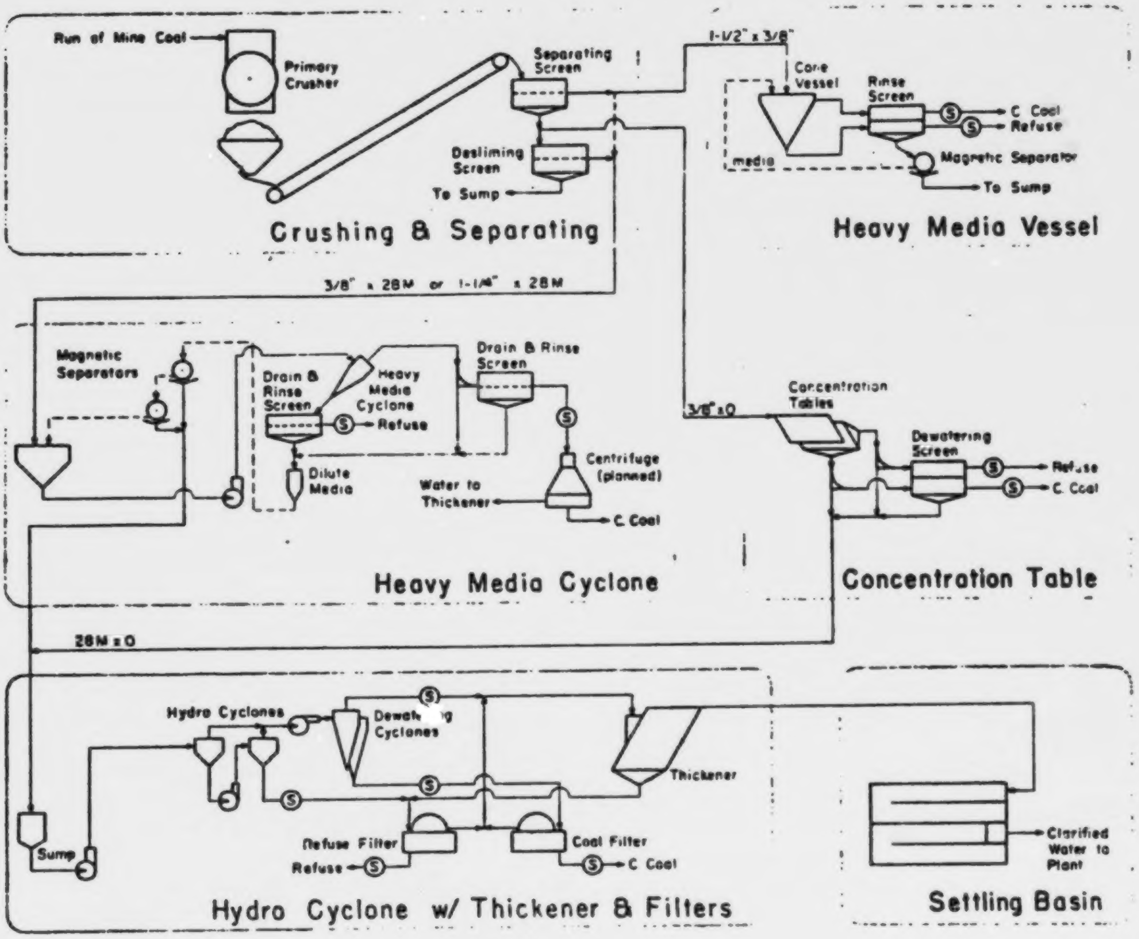
Ray W. Fisher, Program Director
Fossil Energy Program

or

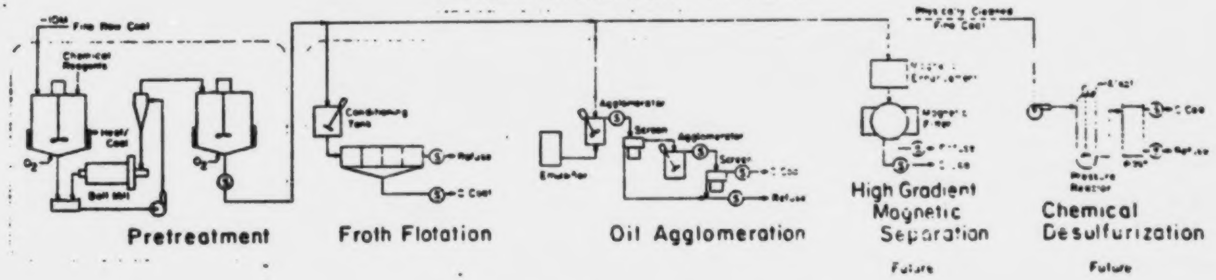
Dave Birlingmair, Head
Coal Preparation

321 Spedding Hall, Ames Laboratory
Iowa State University, Ames, Iowa 50011
(515)294-3758 (FTS 865-3758)

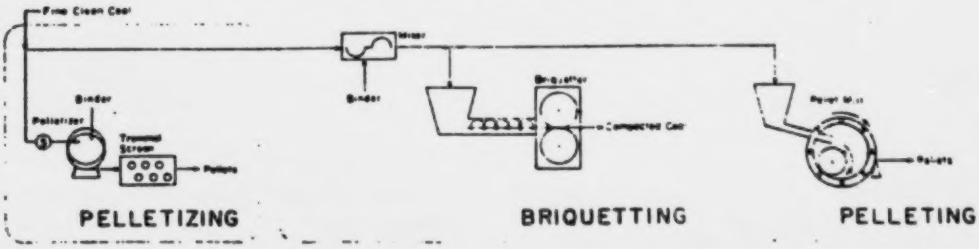
## CONTINUOUS PROCESSING CIRCUITS


Run of Mine Coal
Primary Crusher
Separating Screen
Desliming Screen
To Sump
Crushing & Separating
1-1/2" x 3/8"
Cone Vessel
media
Rinse Screen
C. Coal
Refuse
Magnetic Separator
To Sump
Heavy Media Vessel
3/8" x 28M or 1-1/4" x 28M
Magnetic Separators
Drain & Rinse Screen
Heavy Media Cyclone
Refuse
Dilute Media
Drain & Rinse Screen
Centrifuge (planned)
Water to Thickener
C. Coal
Heavy Media Cyclone
3/8" x 0
Concentration Tables
Dewatering Screen
Refuse
C. Coal
Concentration Table
28M x 0
Hydro Cyclones
Dewatering Cyclones
Thickener
Sump
Refuse Filter
Coal Filter
Refuse
C. Coal
Hydro Cyclone w/ Thickener & Filters
Clarified Water to Plant
Settling Basin

## BATCH PROCESSING CIRCUITS


-10M Fine Raw Coal
Chemical Reagents
Heat/Cool
$O_2$
Ball Mill
$O_2$
Pretreatment
Conditioning Tank
Refuse
C. Coal
Froth Flotation
Agglomerator
Emulsifier
Screen
Agglomerator
Screen
C. Coal
Refuse
Oil Agglomeration
Physically Cleaned Fine Coal
Magnetic Filter
High Gradient Magnetic Separation
Future
Pressure Reactor
C. Coal
Refuse
Chemical Desulfurization
Future

## SIZE RECONSTITUTION CIRCUITS


Fine Clean Coal
Mixer
Binder
Binder
Pelletizer
Trommel Screen
Pellets
PELLETIZING
Briquetter
Compacted Coal
BRIQUETTING
Pellet Mill
Pellets
PELLETING

IOWA STATE UNIVERSITY – COAL PREPARATION FACILITY

## 4.4 NATIONAL INSTITUTE FOR COAL RESEARCH PRETORIA, SOUTH AFRICA

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 25, 1985

Mr. E.F.E. Muller
Fuel Research Institute of South Africa
P.O. Box 217
Pretoria 0001
Transvaal, Republic of South Africa

Dear Mr. Muller:

It is several years since we met; I think the last time was at the Fifth International Conference on Coal Research in Dusseldorf. I hope you and the Fuel Research Institute are well. Following David Osborne's request for information on magnetite, I would like to ask for your further assistance.

Kilborn Engineering have recently been awarded a contract by the Canadian Department of Energy, Mines and Resources for the development and design of a pilot plant for the 'deep cleaning' of pulverized coals (i.e. to a very low ash and sulphur level). The plant will be an extension of the existing pilot plant at Edmonton, and will likely consist of a fine grinding section followed by such process options as froth flotation, oil agglomeration, high density magnetic separation, etc. The initial phase of the project will be a review of existing coal pilot plant installations and of 'deep cleaning' processes.

I am writing to you to request current information on any work being carried out or being planned, on pilot scale 'deep cleaning' processes.

If you are able to provide assistance in this area, I would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B.C.) LTD.

Tony Walters

A.D. Walters
Manager - Coal Preparation

ADW/rlk

## 4.5 NATIONAL RESEARCH COUNCIL OF CANADA, OTTAWA

KILBORN
Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 22, 1985

National Research Council of Canada
Chemical Engineering Section
Division of Chemistry
Montreal Road
Ottawa, Ontario
K1A 0R6

Attention: Mr. C. E. Capes

Dear Sirs:

Kilborn has recently been awarded a contract by the Department of Supply and Services, for the development and design of a pilot plant for the 'deep cleaning' of coal. The plant will be housed in the existing pilot plant at EMR (CANMET) Coal Research Laboratory at Devon, Alberta.

The initial phase of the project, prior to the design, will be a review of cleaning processes and existing pilot plant installations. Fine grinding of coal will be a common stage prior to the selected processes, which are likely to include froth flotation, oil agglomeration and high density magnetic separation.

I am writing to ask if you could assist in supplying current technical information on oil agglomeration practices and details of pilot plant operations. We would, of course, be pleased to comply with any secrecy clauses involving new patents and process modifications.

If you are able to provide assistance in this area, we would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B. C.) LTD.

**A. D. Walters, P.Eng.**
Manager, Coal Preparation

ADW/mr

National Research Council Canada
Division of Chemistry
Ottawa, Canada
K1A 0R6

Conseil national de recherches Canada
Division de chimie

7 January 1986

RECEIVED
JAN 10 1986

**Mr. A.D. Walters**
Manager, Coal Preparation
Kilborn Engineering (B.C.) Ltd.
1380 Burrard Street
Vancouver, B.C.
V6Z 2B7

Dear Mr. Walters:

I apologize for not replying earlier to your letter of November 22 regarding your contract with EMR to develop and design a pilot "deep cleaning" plant for coal. Enclosed please find a paper which we prepared last June which, in table 6, gives you a summary of results of some of our latest work to that time.

When (and if) you need more specific information, I would ask you to sign and return one copy of the enclosed confidentiality agreement. I can then provide you with details of a 6 tph pilot plant design and with a report relating to its operation with Prince Coal from Cape Breton Island. If the interest is great enough, you should consider a meeting here so that we can discuss and try to answer your specific needs.

As you will realize, we use several different flowsheets, depending on the objectives of the plant. This type of information can best be discussed face-to-face.

Yours sincerely,

C. Edward Capes.

C. Edward Capes

Enclosure

/sl

# OIL AGGLOMERATION FOR FINE COAL PROCESSING

C.E. Capes, R.D. Coleman and W.L. Thayer

Division of Chemistry
National Research Council of Canada
Ottawa, Ontario

## Abstract

Loss of coal fines in reject slurries limits the yield of coal cleaning operations. Difficulties in handling fines also limit the extent of physical cleaning in treating coals with finely-disseminated impurities. Selective oil agglomeration allows even extreme fines to be processed and offers some novel approaches for coal cleaning and utilization.

Several features of oil agglomeration processes are discussed here and illustrated with examples from the authors' laboratory. The many possible process configurations are outlined and the scale-up activities at the National Research Council of Canada are briefly described.

## Introduction

The oil agglomeration method is now well known in the coal industry for treatment of fine coal-in-water suspensions (1). These fines can be preferentially wetted and agglomerated by many different oils mixed with the suspensions. Ash-forming impurities remain in suspension and are rejected when the larger agglomerates are recovered, for example by screening. Agglomeration provides perhaps the only practical method for upgrading extremely fine coal to useful products on a large scale.

There is strong interest today in examining processes based on the preferential wetting of coal by immiscible liquids due to the increasing quantity of fines to be dealt with in coal preparation. These fines originate through natural degradation, increasingly-mechanized mining methods and the level of processing required. Size reduction is increasingly necessary to liberate finely-disseminated impurities from the poorer grades of coal which the industry is forced to utilize. This fines problem is further complicated by more stringent environmental constraints, largely focussed on sulphur removal, and by the need to produce finely ground feeds for alternative coal-based fuels and feed stocks (2).

Extreme fines present a problem to conventional coal cleaning methods using tables, jigs, cyclones and even froth flotation. By contrast, there appears to be virtually no lower limit on the particle size suitable for oil agglomeration. In dealing with such problems the coal industry has adopted a philosophy of meeting required production rates and specifications, to the detriment of total plant efficiency (3). The significance of this operational attitude is seen in the cost breakdown of cleaned coal which consists of three components:

- run-of-mine coal cost as delivered to the wash plant
- cleaning cost, and
- the cost associated with disposal of rejected material.

Of these three costs, the cleaning component was found to be comparatively minor while the fine waste coal problem is very important, both through the cost of disposal and through the mining cost of the lost coal values (3). Recovery and utilization of these lost fines could do much to reduce the cost of cleaned coal.

This paper begins with an overview of the most important characteristics of oil agglomeration applied to fine coal treatment. Aspects of impurity rejection, particle recovery and dewatering are discussed. The many possible process configurations utilizing the best features of oil agglomeration are considered. Finally current activities at the National Research Council of Canada (NRCC) to commercialize the process, especially in its application to waste fines recovery at preparation plants, are briefly described.

## A Family of Agglomeration Phenomena

The oil agglomeration of fine coal in the context of this paper differs from normal size enlargement not only because it takes place in a water phase (that is, three phase agglomeration), but also because it is selective in the agglomeration of carbon components which can then be separated from the hydrophilic impurities not wetted by the oil. The major factors affecting oil agglomeration are thus similar to those affecting froth flotation, the most common method currently practiced industrially for fine coal slurry treatment. Process parameters of importance are the amount and type of collecting oil, degree and type of agitation, pulp density, size consist, and wetting properties of the coal.

The most significant operating parameter, however, is the oil concentration. With a typical fine coal stream from a preparation plant containing particles all finer than 0.5 mm, a variety of types of agglomerates is

Proc. 4th International Symposium on Agglomeration, Toronto, June 2-5, 1985, Iron and Steel Society, Warrendale, PA.

obtained as the amount of oil is increased from, say, less than 3 to 5 wt.%, into the range 5% to 15% and beyond the 15 wt.% level. In the lower range of oil loading, only a few pendular bridges can form between the particles and an unconsolidated floc structure is formed. When such flocs are separated on a screen of suitable size, yield is poor because of the poor integrity of the agglomerates. The flocs tend also to trap inorganic ash components and moisture which drains only slowly by gravity alone. With larger amounts of oil in the 5-15% range, the chain-like floc structure is replaced by more compact three-dimensional agglomerates. This is the funicular region of interparticle void filling in which the number of oil junctions per particle has increased and pendular bridges have partially coalesced into a network structure. Such agglomerates are more discrete in nature and ash particles are able to drain more easily with the suspending aqueous phase. The agglomerates grow in size and reach a peak of strength and compaction near the capillary region when the void space in the interior of the agglomerates is just filled with oil. Beyond this 15-20% oil range for the typical minus 0.5 mm particles noted above, the agglomerates contain too much oil to remain relatively firm. They become soft, paste-like, cohesive lumps in which the solids are essentially dispersed in the bridging liquid. Interphase particle transfer can be operated in this region using appropriate mixing equipment.

It is evident, on the one hand, that the oil agglomeration process is capable of producing a variety of agglomerated coal products while, on the other hand, these products and processes provide a number of answers to fine coal treatment objectives. That is, the process impacts on fine coal recovery, impurity rejection, product dewatering and refuse tailings disposal.

## Recovery Aspects

As has been amply demonstrated in the literature, most oils of industrial interest can be used in the oil agglomeration of fine bituminous coal, with virtually quantitative recovery of carbon units if appropriate mixing conditions are used (1). This excellent recovery characteristic is due to the integrity of the oil-coal bond which is relatively much stronger than the air-coal bond operating in froth flotation, the other major surface chemical process used in the wet concentration of fine coal.

This greater strength of the oil-water-coal system is an advantage in that intensive mixing of sufficient duration can be used to disperse the oil and cause inter-particle contact without the danger of permanently destroying the aggregates. Thus adequate phase mixing can be introduced so that even the micron-sized particles likely to be encountered in coal preparation, using even the relatively denser and more viscous inexpensive oils of economic interest, can be readily agglomerated using acceptable mixing times and compact equipment (4). In addition positive separation devices, such as screens with high throughput and short residence time, can be used to recover the agglomerated products without excessive losses due to agglomerate breakdown. Water sprays and other forms of washing can also be used to remove trapped impurities without destroying the agglomerates.

The above discussion assumes adequate wetting of the coal particles by the bridging oil. This condition normally occurs with the hydrophobic higher rank coals. Lower rank coals (subbituminous, lignite), oxidized coals and coals containing certain clays and other surface active components may present a less wettable hydrophilic surface. Wetting agents (5) as well as heavy oils and more aromatic oils (6,7) as bridging liquids have been used to improve recovery of these more difficult-to-wet coals.

A case in point is the tests shown in Table 1 on thickener underflow from a preparation plant treating a high volatile bituminous C coal in the foothills region of Western Canada. This coal is known not to respond well to flotation and gave poor recoveries when agglomerated with No. 2 fuel oil. When various amounts of this light oil were mixed with this slurry, some visual evidence of coal flocculation was apparent, but the agglomerates could not be separated by screening. The emulsified mixture blinded the screens and only very slow drainage could be obtained. With No. 4 fuel oil as seen in Table 1, less than 50% of the combustible matter was retained on the screen after prolonged drainage, apparently due to poor oil-coal wetting and weak agglomerates which passed through the screen with the mineral components. Better agglomeration was not obtained when the slurry was ground in an attrition mill in an attempt to produce fresher carbon surfaces to improve oil wetting.

As indicated in Table 4, good agglomeration and combustibles recovery on a 100 mesh screen was achieved with this same refuse slurry when the finest components (minus 170 mesh) were first removed from it. A probable explanation for this improved behaviour is related to the fact that much of the clay material is removed during this initial "desliming". One can postulate (8) that humic materials leached from the coal form humic acid in the slurry which can be adsorbed by the clays present rendering them somewhat hydrophobic. If oil is added to the original clay slurry containing large amounts of clay with adsorbed humic acid, then the oil is adsorbed by the clay to form an oil/water clay-stabilized emulsion which interferes with the coal agglomeration and blinds the separating screen. Removal of the finest components and clays of the original slurry

Table 1 - Effect of Desliming at 170 mesh on Agglomeration of Bituminous C Tailings from Western Canada

| Starting Ash<br>wt. % | Wt. % No. 4<br>Oil Added<br>d.b. Feed | Agglomerates Recovered on 100 mesh Screen<br>Ash<br>wt. % | <br>Combustible Recovery<br>wt. % |
|---|---|---|---|
| Original Tailings | | | |
| 51.6 | 3.0 | 13.4 | 23.8 |
| 45.1 | 5.5 | 11.9 | 37.5 |
| 43.4 | 6.7 | 21.1 | 36.8 |
| Plus 170 Mesh Material from Original Tailings | | | |
| 17.2 | 0.9 | 13.1 | 84.7 |
| 17.2 | 2.2 | 14.3 | 92.5 |
| 17.2 | 3.2 | 13.9 | 85.1 |

Table 2 - Comparison of Oil Agglomeration and Flotation for Cleaning of Waste Coals at -25  m (9)

| Sample | Method (Test) | Products | Weight % | Analysis %<br>Ash | <br>Com | Distribution %<br>Ash | <br>Com |
|---|---|---|---|---|---|---|---|
| Canmore | Agglomeration | Coal conc | 93.7 | 10.9 | 89.1 | 64.6 | 99.2 |
| | (Test 16) | Reject | 6.3 | 88.9 | 11.1 | 35.4 | 0.8 |
| | | Feed | 100.0 | 15.8 | 84.2 | 100.0 | 100.0 |
| | Flotation | Coal conc | 86.2 | 9.1 | 90.9 | 46.2 | 94.4 |
| | (Test 13) | Reject | 13.8 | 66.4 | 33.6 | 53.8 | 5.6 |
| | | Feed | 100.0 | 17.0 | 83.0 | 100.0 | 100.0 |
| McIntyre | Agglomeration | Coal conc | 91.9 | 18.0 | 82.0 | 70.7 | 98.4 |
| | (Test 17) | Reject | 8.1 | 84.7 | 15.3 | 29.3 | 1.6 |
| | | Feed | 100.0 | 23.4 | 76.6 | 100.0 | 100.0 |
| | Flotation | Coal conc | 58.4 | 11.8 | 88.2 | 28.8 | 67.7 |
| | (Test 14) | Reject | 41.6 | 41.0 | 59.0 | 71.2 | 32.3 |
| | | Feed | 100.0 | 23.9 | 76.1 | 100.0 | 100.0 |
| Coleman | Agglomeration | Coal conc | 94.6 | 15.6 | 84.4 | 76.8 | 98.8 |
| | (Test 18) | Reject | 5.4 | 82.5 | 17.5 | 23.2 | 1.2 |
| | | Feed | 100.0 | 19.2 | 80.8 | 100.0 | 100.0 |
| | Flotation | Coal conc | 60.8 | 10.7 | 89.3 | 33.7 | 67.3 |
| | (Test 15) | Reject | 39.2 | 32.7 | 67.3 | 66.3 | 32.7 |
| | | Feed | 100.0 | 19.3 | 80.7 | 100.0 | 100.0 |

prevents this interference upon oil addition and restores the hydrophobic/hydrophilic distinction between coal and its mineral impurities.

## Impurity Rejection

Oil agglomeration attains high recovery levels because the impurity particles which it rejects are virtually barren of coal matter. An important consequence of this fact is illustrated in Table 2 which reports some results from a study of the beneficiation of some waste Canadian coals by flotation and agglomeration (9). With the three coals reported here, agglomeration provided a higher recovery range (98.2 to 99.2%) than flotation (67.3 to 94.4%) and, as expected from these high recoveries, agglomeration rejected tailings which were almost barren of coal (82.5 to 88.9% ash). Because of this elimination of only the higher ash material, however, the agglomeration tests lead to higher ash contents in the recovered product than did the flotation tests.

Further evidence that oil agglomeration may recover particles containing substantial levels of impurites is given in Table 3. These data concern agglomerates, recovered in a pilot plant operating on thickener underflow at an Eastern Canadian coal washery treating bituminous coal, which were analyzed by first extracting their bridging No. 2 fuel oil and water content with alcohol and xylene washes and subjecting the resulting fine coal contained in the agglomerates to screen and sink-float analyses using halogenated hydrocarbon mixtures as dense media. Table 3 shows that coal of much-reduced ash content can be produced from these agglomerates by using low density separating liquids (c.f. the 1.30 and 1.30 - 1.60 g/mL floats fractions). It is evident that agglomeration is not the most selective process, but wets and recovers most

**Table 3 - Size, Ash and Density Analyses of Particles in Agglomerates from Thickener Underflow**

| Size | Original Agglomerates | | 1.30 g/mL Floats | | 1.30-1.60 g/mL Floats | | 1.60 g/mL Sinks | |
|---|---|---|---|---|---|---|---|---|
| Tyler Mesh | Wt. % | Ash wt. % | Wt. % | Ash wt. % | Wt. % | Ash wt. % | Wt. % | Ash wt. % |
| + 28 | 15 | 21 | 13 | 1.3 | 5 | 8.8 | 13 | 80 |
| + 35 | 8 | 23 | 13 | 1.2 | 5 | 9.2 | 16 | 79 |
| + 48 | 8 | 34 | 10 | 1.1 | 4 | 9.0 | 15 | 80 |
| + 65 | 9 | 33 | 11 | 1.1 | 4 | 9.0 | 16 | 81 |
| +100 | 7 | 33 | 9 | 1.3 | 3 | 9.6 | 14 | 80 |
| +150 | 5 | 20 | 6 | 1.5 | 3 | 6.7 | 7 | 77 |
| +200 | 4 | 17 | 4 | 2.3 | 5 | 6.7 | 4 | 69 |
| +250 | 2 | 13 | 2 | 3.6 | 3 | 7.2 | 2 | 67 |
| +325 | 3 | 15 | 3 | 5.3 | 5 | 7.9 | 2 | 66 |
| -325 | 40 | 11 | 29 | 8.3 | 63 | 8.9 | 11 | 32 |
| % Total Wt. | 100 | | 44 | | 35 | | 21 | |
| Avg. % ash | 19.6 | | 3 | | 8.7 | | 74 | |

of the coal-containing particles in a suspension, even some containing high ash levels. Apparently oil wettability is unaffected by (or "swamps") quite substantial levels of hydrophilic impurity "islands" in the surface of coal particles and forms sufficiently strong bonds to allow particles of quite high ash levels to be recovered in the aggregates.

It should be appreciated that the high recovery characteristic of oil agglomeration and its rejection of only very high impurity content particles in fact mitigates against the production of agglomerates with very low ash levels. In a study reported in another paper at this Symposium, the objective was to evaluate oil agglomeration for cleaning coal to less than 1.5% ash using several coal feedstocks (10). Minimum ash contents of the agglomerates produced in this study are shown in Figure 1 as a function of the initial ash content of the coal used in the experiments. These minimum ash contents could only be achieved at mean particle diameters of 5 to 6 microns in all cases, the minimum size produced in the laboratory agitated-media mill used in the work. Thermal value recoveries of 99% and over were achieved in all the tests cited. As expected from considerations of liberation phenomena in crushing, there is a higher probability to produce low ash coal particles as the ash content of the coal to be crushed decreases. Hence in Figure 1 there is a very good direct correlation between the ash contents of the feed coals and of the agglomerated products. The economic goal of virtually quantitative thermal value recovery and the rejection of only the highest ash particles during oil agglomeration requires grinding to extreme fineness, as in the work cited in Figure 1, in order to produce particles approaching "pure" coal and "pure" impurities so that very low ash contents can be produced.

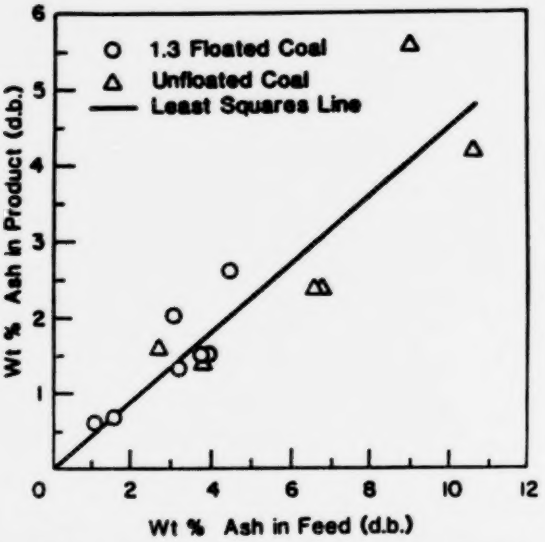


Figure 1 - Relationship between ash contents of feed coals and agglomerated products for six different bituminous coals. (Floated feed treated at 1.3 sp. gr. on -5 mm grind; agglomeration on 5-6 μm grind with 99% combustibles recovery in all cases).

In order to improve the selectivity of oil agglomeration, a process which combines agglomeration with density separation has been patented (11). It is doubtful if such a scheme can be used economically on a large scale due to the difficulties inherent in fractionating very fine coal by dense liquid flotation. Indeed, the relatively higher ash content of the minus 200 mesh fractions of the 1.30 floats in Table 3 is probably due to the difficulty of obtaining clean density separations with fine materials, even on an analytical laboratory scale.

An alternative approach to improved selectivity for oil agglomeration is to operate

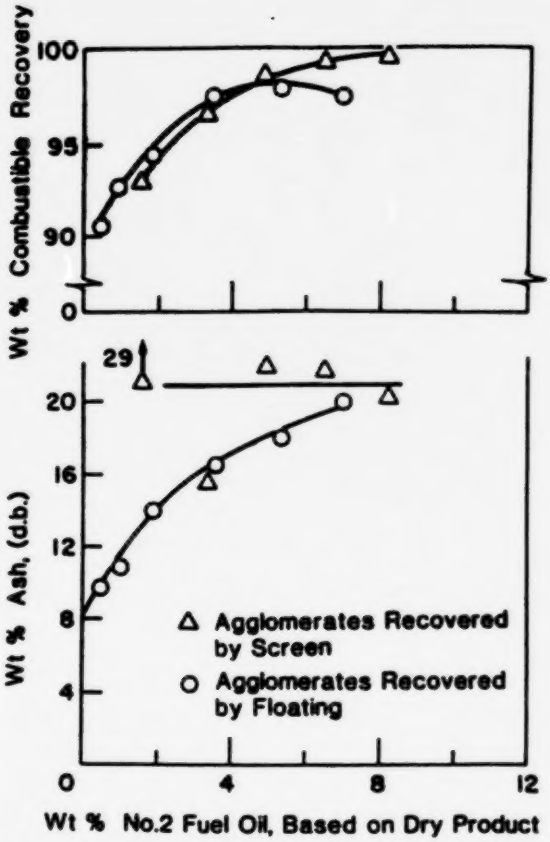


Figure 2 - Effect of agglomerate recovery method on product ash and recovery levels.

at the lowest possible oil levels while still maintaining acceptable but lower recoveries. When only 1 or 2% (or less) oil is used for agglomeration, the strongest floc-agglomerates would be expected to contain the coal particles with lowest ash levels. The flocs so produced are inevitably very fragile and cannot satisfactorily be recovered by the screening methods used for higher oil levels. Floc skimming or flotation can be used to recover such agglomerates, with careful attention to a subsequent washing step to remove any extraneous ash trapped in the "matte" of recovered flocs. The approach is illustrated by the data in Figure 2 using a -28 mesh Upper Freeport Seam coal from the U.S. Ash, density and size analyses of this coal are given in Table 4. Considerably reduced ash levels are attained (in Figure 2) using the lowest oil levels combined with floc flotation and careful washing of the product agglomerate-flocs.

Tables 3 and 4 and Figure 2 also illustrate the importance to ash rejection of the agglomerate recovery method used in oil agglomeration. Specifically, the disadvantage of using high capacity screens to recover agglomerates when oversize impurity particles are contained in the slurry to be treated is illustrated in both cases. Such particles are evident in the plus 100 mesh fractions of the 1.60 g/mL sinks material in Tables 3 and 4. If a 100 mesh screen is used for agglomerate recovery, these high ash particles report with the agglomerated product. Simple calculations indicated that removal of this fraction could result in reduction of the overall agglomerate ash content from 20% down to about 7.5% for the material in Table 3. Reslurrying of the agglomerates and subjecting them to bubble flotation or to tabling verified that agglomerates of about 6-7% ash content could be produced in this way with greater than 98% recovery of thermal values. Similarly Figure 2 shows the greater ash content of product obtained when the agglomerates were recovered by screening, thus trapping the high ash +100 mesh material contained in the feed particles.

Thus it is seen that the impurity level obtained in the oil agglomeration of coal depends in a complex way on the amount of oil used and the form of agglomerates produced, as well as on the method of agglomerate recovery. A further important factor is the physical and

Table 4 - Size, Ash and Density Analyses of a Sample of Upper Freeport Seam Coal

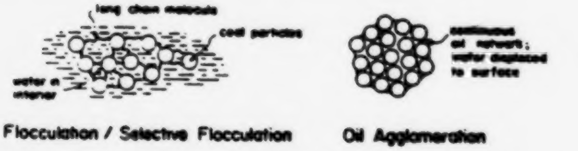
| Size Tyler Mesh | Total Sample Wt. % | Total Sample Ash wt. % | 1.30 g/mL Floats Wt. % | 1.30 g/mL Floats Ash wt. % | 1.30-1.60 g/mL Floats Wt. % | 1.30-1.60 g/mL Floats Ash wt. % | 1.60 g/mL Sinks Wt. % | 1.60 g/mL Sinks Ash wt. % |
|---|---|---|---|---|---|---|---|---|
| + 28 | 6 | 51 | 2 | 2.8 | 4 | 17 | 16 | 73 |
| + 35 | 12 | 28 | 9 | 2.8 | 10 | 16 | 16 | 70 |
| + 48 | 14 | 26 | 15 | 2.4 | 14 | 15 | 14 | 65 |
| + 65 | 18 | 22 | 22 | 3.7 | 17 | 14 | 13 | 64 |
| +100 | 17 | 19 | 23 | 2.1 | 15 | 14 | 12 | 64 |
| +150 | 10 | 18 | 15 | 2.2 | 10 | 13 | 5 | 62 |
| +200 | 7 | 17 | 9 | 2.0 | 9 | 10 | 5 | 60 |
| +250 | 3 | 18 | 2 | 2.3 | 5 | 8 | 5 | 44 |
| +325 | 5 | 18 | 2 | 2.7 | 7 | 8 | 4 | 48 |
| -325 | 8 | 21 | 1 | 4.1 | 9 | 9 | 11 | 32 |
| % Total Wt. | 100 | | 32 | | 37 | | 31 | |
| Avg. % ash | 23.3 | | 2.6 | | 13.0 | | 61.2 | |

chemical properties of the oil used, as has already been discussed in some detail in the literature (1). In essence, it appears that some of the denser and more viscous oils contain higher levels of inorganic polar functional groups which are able to attach to the surface of the ash-forming particles of coal and so "condition" them to become hydrophobic, report with the carbonaceous particles of the agglomerates and cause higher product impurity levels.

## Moisture Reduction

A major difficulty with fine coal is its high moisture retention capacity caused by its large surface area, with attendant problems of poor flow properties and propensity to freeze in winter. Because of the mechanism of agglomeration, in which interparticle voids are filled with oil and particles are rendered very hydrophobic, the suspending phase is effectively excluded, in contrast to the flotation and flocculation processes in which suspending liquid remains in the aggregate interior in large amounts (see Figure 3). With simple gravity drainage on a screen, the moisture content can be reduced to less than 10% by agglomeration without the need for thermal drying, provided that the size of agglomerates is larger than about 2 mm. When smaller agglomerates, say less than 1 mm diameter, are produced with lower oil levels, mechanically-assisted dewatering in a centrifuge can be employed to attain low moisture levels rapidly without thermal drying. Detailed investigations of these moisture retention phenomena have been published previously (12-14).

During the preparation and transportation of bulk commodities such as coal, periods of storage from a few days to perhaps months inevitably occur. The moisture shedding ability of hydrophobic oil agglomerates can be used during these periods to reduce the moisture and even ash content of recovered fine coal. This is illustrated in Table 5 which follows the ash and moisture content of an approximately 10 ton, 5-ft high pile of agglomerates, sampled in the centre of the pile during a period without rain and daytime temperatures of about 28°C. This test and other tests with much larger piles of agglomerates verified that considerable assistance in moisture and ash reduction can be obtained through natural drainage.



Flocculation / Selective Flocculation      Oil Agglomeration

Figure 3 - Schematic representation of moisture retention in aggregation by polymeric flocculants and by oil wetting.

## Process Configurations

It has already been noted that a variety of agglomerate forms are possible depending on the amount of bridging oil used. Other factors affecting the outcome of a coal agglomeration process are the method and intensity of agitation, coal rank and oil type, as well as the method used to recover agglomerates and other post-agglomeration treatments. The basic steps which may be used in agglomerate formation, and equipment suited to accomplish various process objectives, are summarized in Figure 4, adapted from our 1971 publication on the subject (13).

Not every element shown in the processing sequence in Figure 4 need be incorporated into the oil agglomeration technique for a given application. For example, the separation stage between high and low intensity mixing is often omitted, as is the oil recovery and reuse phase. The diversity of processes and applications is evident from the papers on the subject included in this Symposium. Likewise the open literature on the subject has grown exponentially over the past decade. A recent literature review uncovered more than 100 patents on the subject over the past ten years, indicating a strong commercial interest in the field (15).

Many variations on the basic coal agglomeration flow-sheet have been described, including:

(a) split feed to agglomerate only the finest components and further agglomeration of residual slurry (16).
(b) multi-stage mixing and processing (17).
(c) nucleation with coarse coal and recycled agglomerates to improve the kinetics of

Table 5 - Effect of Time on the Moisture and Ash Content of a Pile of Agglomerates

| Drainage Time (Days) | Wt. % Moisture (wet basis) | Wt. % Ash (dry basis) |
|---|---|---|
| 0 | 41.6 | 14.8 |
| 1 | 26.1 | 12.8 |
| 2 | 18.3 | 12.2 |
| 5 | 20.1 | 12.6 |
| 6 | 17.9 | 13.4 |
| 7 | 17.8 | 11.6 |

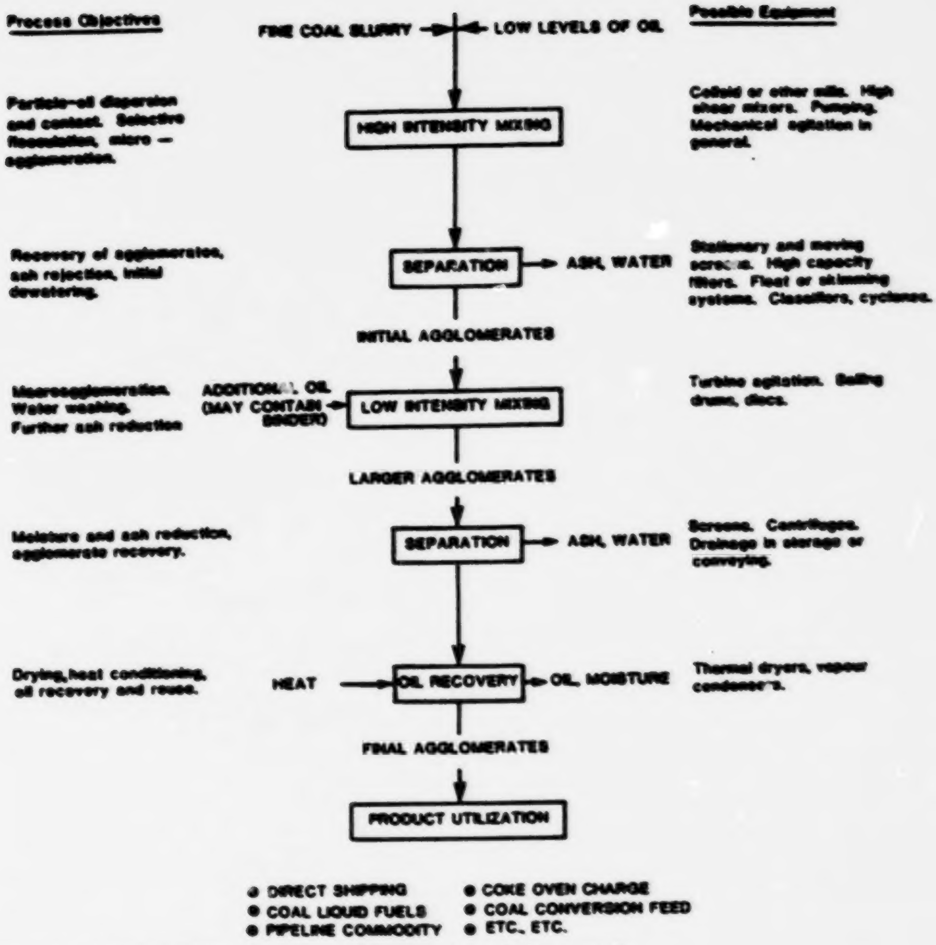

Process Objectives
FINE COAL SLURRY
LOW LEVELS OF OIL
Possible Equipment
Particle-oil dispersion and contact. Selective flocculation, micro — agglomeration.
HIGH INTENSITY MIXING
Colloid or other mills. High shear mixers. Pumping. Mechanical agitation in general.
Recovery of agglomerates, ash rejection, initial dewatering.
SEPARATION
ASH, WATER
Stationary and moving screens. High capacity filters. Float or skimming systems. Classifiers, cyclones.
INITIAL AGGLOMERATES
Macroagglomeration. Water washing. Further ash reduction
ADDITIONAL OIL (MAY CONTAIN BINDER)
LOW INTENSITY MIXING
Turbine agitation. Balling drums, discs.
LARGER AGGLOMERATES
Moisture and ash reduction, agglomerate recovery.
SEPARATION
ASH, WATER
Screens. Centrifuges. Drainage in storage or conveying.
Drying, heat conditioning, oil recovery and reuse.
HEAT
OIL RECOVERY
OIL, MOISTURE
Thermal dryers, vapour condensers.
FINAL AGGLOMERATES
PRODUCT UTILIZATION
● DIRECT SHIPPING
● COAL LIQUID FUELS
● PIPELINE COMMODITY
● COKE OVEN CHARGE
● COAL CONVERSION FEED
● ETC., ETC.

Figure 4 Process configurations for oil agglomeration of fine coal.

agglomeration, reduce oil consumption and improve dewatering.

(d) agglomerate separation by flotation, sedimentation, dense media, in addition to the most often used screen separation.

(e) recovery and recycle of the agglomerating oil (19).

## Current Activities at NRCC

The inescapable fact relevant to all applications of the oil agglomeration process is the large component of the operating cost due to the oil. Capital and fixed costs are generally low due to the simplicity of the equipment and process flowsheet so that if the cost of the oil charged to the progress can be reduced or eliminated, the economics becomes quite attractive for fine coal recovery. The oil is effectively captured in the agglomerates so that economic justification of the process depends on the extent to which the oil cost can be recovered when the agglomerates are utilized.

The current program at the National Research Council is targeted on what is considered to be the most economically attractive application of oil agglomeration today. That is, the emphasis is on improved preparation plant yields through recovery of lost fine coal values in refuse slurries and tailings sludges. As noted already in these cases, agglomerant cost can be offset by zero-value (or even negative value) feed material, since mining and discard treatment costs are included in the production cost of the currently marketed clean coal product. This application provides secondary benefits which can be credited to the process, such as environmentally more acceptable clean tailings streams and extended tailings pond life due to reduced volumes of discard fines.

A demonstration program is underway at NRC using a mobile coal agglomeration pilot plant to treat various refuse fines streams at operating preparation plants. A schematic flowsheet of the operation capable of recovering about 5 tph of beneficiated fines is shown in Figure 5. Standard equipment consisting of turbine agitated tanks in series is used. Oil dispersion and initial agglomeration occurs in a high shear mixer with an average residence time of one minute or less. Agglomerate consolidation and subsequent growth then takes place in downstream turbine-agitated tanks with less intensive mixing and residence times of the order of two to four minutes. Pilot plant test results from several plant sites are summarized in Table 6.

Following several years of laboratory research (1), in which most aspects of the recovery and beneficiation of coal fines were examined, it was decided that a mobile plant operating at the plant sites would be an efficient way to encourage adoption of the technology by industry. Not only would this allow the processes and techniques developed to be tested against real plant situations of variable feeds, plant upsets, etc., but the production of tonnage quantities of good quality coal from reject streams would also provide convincing evidence of process viability and economics. This has proven to be correct with several commercial installations to produce agglomerated recovered refuse fines in the 20-40 tph capacity range either operating or under consideration.

It should be evident that in any process to treat coal fines, the product must not only be recovered and deashed but must also be rendered to a form suitable for transportation to the place of final end use. In the case of waste fines recovery where the agglomerates may represent perhaps 10% of the output from a cleaning operation, the agglomerates can be mixed with the coarser coal fractions for shipment. Adequate account should be taken of the safety aspects of possible volatile components of the bridging oil in this situation, but it can be expected that the relatively soft microagglomerates would be advantageous to the overall product in reducing dusting problems and helping with freezing problems in winter. Alternatively high ash fines recovered as agglomerates could be used directly at the cleaning plant to fire coal driers.

An ideal application for coal agglomerates is in the preparation of coal liquid mixtures (CLM) to displace oil in utility boilers and other boiler and furnace applications in industry (20). The thermal value of the oil from the agglomeration step is then utilized in the final CLM fuel. Waste fines recovered in this way provide a cheap source of feed coal and little or no further size reduction is needed to obtain the fine coal desirable in the

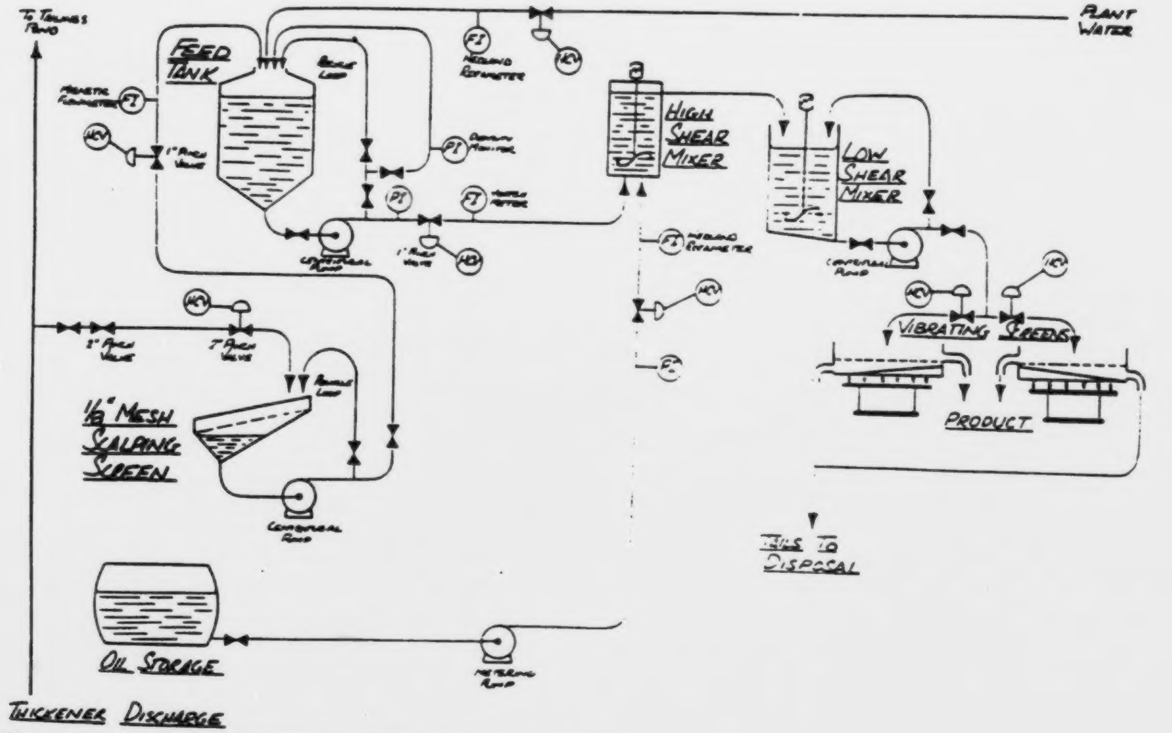


Figure 5 Process flowsheet for NRCC mobile pilot plant.

Table 6 - Agglomeration Results with Bituminous Coal Fines at Several Plant Test Sites

| Location of Plant | Feed Source | Mean Particle Size | Feed Solids wt. % | Oil Usage wt. % d.b. | Ash Content, wt. % d.b. Feed | Ash Content, wt. % d.b. Agglomerates | Ash Content, wt. % d.b. Discard | Recovery of Combustibles wt. % |
|---|---|---|---|---|---|---|---|---|
| West Virginia (1978) | flotation feed | 25 µm | 20 | ~10 based on feed | 27 | 8.5 | 90 | 95 |
| West Virginia (1978) | flotation tailings | n.a. | 19 | n.a. | 31 | 10 | 89 | 95 |
| West Virginia (1978) | refuse filter underflow | n.a. | 43 | n.a. | 35 | 11 | 80 | 87 |
| Cape Breton Island (1979) | centrifuge centrate | 17 µm | 2-3 | >10 | 12 | 2 | n.a. | n.a. |
| Cape Breton Island (1982) | aged refuse pile | 32 mesh | 24 | ~2 based on feed | 30 | ~10 | 83 | 94 |
| Cape Breton Island (1983) | thickener underflow | 48 mesh | 26 | ~5 based on product | 39 | ~15 | 82 | 96 |
| Cape Breton Island (1983) | pond | 200 mesh | 23 | ~9 based on product | 33 | 10 | 84 | 96 |
| Pennsylvania (1983) | pond | minus 100 mesh | 13 | ~6 based on feed | 26 | 7 | >75 | >90 |
| Virginia (1984) | thickener underflow | 250 mesh | 21 | 4 based on feed | 37 | 16 (10 after further wash) | 82 | 93 |

CLM. Utilization of the CLM in the coal preparation plant or in associated steelworks is an ideal outlet for the recovered fine coal. Physical mixtures of coal, water and liquid fuels in many different proportions have been prepared at NRCC from agglomerates and future applications may include feed slurries for chemical coal conversion processes (2, 7).

## Acknowledgments

Our colleagues A. Bennett, S. Croteau, A. Fouda, K. Jonasson, and F. Toll contributed in various ways to the work summarized here. We also thank the following companies for their cooperation: American Minechem Corp., Arcanum Corp., Cape Breton Development Corp., Coaltek Ltd., Guildcraft (1978) Ltd., Scotia Liquicoal Ltd.

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NRCC No. 24887

## 4.6 AUSTRALIAN COAL INDUSTRY RESEARCH LABORATORY, NEW SOUTH WALES

KILBORN
Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 26, 1985

Mr. Arthur Le Page
General Manager and
Director of Research
Australian Coal Industry
Research Laboratory Ltd.
P.O. Box 63
North Ryde
New South Wales 2113
Australia

Dear Art:

We were sorry you were unable to attend the International committee meeting in Vancouver and hope you are now fully recovered. We look forward to seeing you next year in Edmonton and Vancouver.

Following David Osborne's recent request for information on magnetite specifications, I would request some further assistance. Kilborn Engineering have recently been awarded a contract by the Department of Energy, Mines and Resources for the development and design of a pilot plant for the 'deep cleaning' of pulverized coals (i.e. to a very low ash and sulphur level). The plant will be an extension of the existing pilot plant at Devon, near Edmonton, and will likely consist of a fine grinding section followed by such process options as froth flotation, oil agglomeration, high density magnetic separation, etc. The initial phase of the project will be a review of existing coal pilot plant installations and of 'deep cleaning' processes.

I am writing to you to request current information on work being carried out as being planned, on pilot scale 'deep cleaning' processes.

If you are able to provide any assistance in this area, I would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B.C.) LTD.

Tony Walters

**A.D. Walters**
Manager - Coal Preparation

ADW/rlk

ACIRL
COAL RESEARCH
AUSTRALIAN COAL INDUSTRY RESEARCH LABORATORIES LTD.
INCORPORATED IN N.S.W.
REGISTERED OFFICE 14-30 DELHI ROAD, NORTH RYDE, N.S.W. 2113
TELEPHONE: 887 3777 TELEX: 27251

CCG/jr

December 18, 1985

Mr. A.D. Walters,
Manager Coal Preparation,
Kilborn Engineering (B.C.) Ltd.,
1380 Burrard Street,
VANCOUVER V6Z2B7,
CANADA

RECEIVED
JAN 2 1986
Ans'd..................

Dear Mr. Walters,

I have the sad duty to inform you that Arthur Le Page passed away on Sunday December 15, 1985 following a prolonged illness of which you are aware.

With regard to the enquiries in your letter dated November 26, 1985 concerning "deep cleaning" pilot plants in Australia, there is only one of which I am aware :

- The IPTACCS process involving selective agglomeration of finely ground coal during pipeline transport - The Broken Hill Proprietary Company Limited - contact Dr. D.E. Mainwaring, Central Research Laboratories, The BHP Co. Ltd., P.O. Shortland, N.S.W. 2307 Australia.

  An abstract from the BHP Technical Bulletin is attached which may assist.

Other than that, the only investigations in this area are -

- Column Flotation by the BHP Central Research Laboratory - Contact Dr. S. Nicol, and
- The COMOCO process - an offshoot of the OTISCA process I believe - COMOCO Fuels, P.O. Box 57, Crows Nest, N.S.W. 2065, Australia, Telex AA25468 (SECCO) - Contact Dr. L. Williams.

I trust that this information will be of some help to you in your project work and look forward to hearing from you again.

Yours sincerely,

..................
Colin Graham,
Manager - Coal Preparation

# Integrated Pipeline Transportation and Coal Separation System (IPTACSS) — Pilot Demonstration Plant

**G. H. Mead**
**Senior Development Engineer**
**Central Engineering Division**
**Head Office**

**Abstract:**
Following encouraging results of tests on a 50 mm diameter, 100 metre long pilot pipeline loop at BHP Central Research Laboratories, Shortland, NSW on various NSW coals, the next step in the development of IPTACSS has been the installation of a 100 mm diameter 1.6 km long pipeline with its associated preparation, storage and recovery equipment.

BP Australia, who were working independently on coal cleaning via oil agglomeration, have pooled their experience and technology with BHP and a pilot plant has been constructed under a joint arrangement between the two companies.

This pilot demonstration experimental plant of 30—50 tonnes per hour capacity produces sufficient coal at an industrially significant scale of operation for product evaluation trials including coke oven battery, blast furnace and thermal power generation trials together with design and operating data for evaluation of large scale commercial installations.

**Reference: Mead, G. H. "Integrated Pipeline Transportation and Coal Separation System (IPTACSS) — Pilot Demonstration Plant". *BHP Tech. Bull.* 23 (2), Nov. 1979, p. 48.**

Key Words: pipeline, coal, coke, coal

Motivated initially by the desire to achieve lower capital and operating costs in the transportation of coal within the southern coalfields in NSW, Central Engineering Division and Central Research Laboratories turned to slurry pipelines and selective agglomerating techniques as a possible solution.[1-6]

The Integrated Pipeline Transportation and Coal Separation System, IPTACSS, is a new concept in the handling, cleaning, preparation, storage and transportation of coals from the coal mine to steelworks coke ovens, to power generating stations and to coal conversion plants.

Having developed the concept over the last 4 years with the aid of a 50 mm diameter 100 metre long pipeline pilot plant at Central Research Laboratories to simulate a number of areas of the system, a pilot demonstration experimental plant capable of handling approximately 30 tonnes per hour of raw coal has been recently installed in the Newcastle area of New South Wales (see photograph on inside back cover).

This pilot plant incorporates features developed by BP Australia relating to hydrocarbon recovery. BP Australia have for some time been carrying out research along similar lines to BHP and co-operation between our research departments has been proceeding.

The purpose of this pilot demonstration experimental plant is to produce sufficient material in a reasonable time to demonstrate in a commercially sized operating coke ovens plant or a boiler plant (depending on the coal being used) that coal transported by the IPTACSS coal slurry pipeline using selective agglomeration techniques is both technically and economically viable. It will demonstrate the capabilities of the equipment and design layouts within the plant and furnish design data for the design of commercially sized installations.

Due to the differences in types and quality of coal mined in varying locations, the availability of water and hydrocarbons, the relative locations of mines and ports and steelworks, power stations and process plants, the geography of a country and environmental considerations, different overall layouts of IPTACSS will result. This pilot plant has the essential elements to give the data necessary to design a system for all of these circumstances. The flexibility of the pilot plant is such that any flow patterns and arrangement of equipment to suit any coals or coal bearing wastes can be readily carried out.

The pilot plant, fully developed, will include a raw coal stockpiling area to feed the plant and consists of dumping facilities, crushing, grinding, coal slurrying, hydrocarbon injection equipment, pipeline loop, hydrocarbon recovery equipment, storage and blending ponds, dewatering equipment, water clarification ponds and clean agglomerated coal product loading bins.

With the recent completion of the first stage of the Integrated Pipeline Transportation and Coal Separation System pilot demonstration plant, scheduled test work on coal and plant is about to commence.

It is anticipated that the pilot plant will become a research and demonstration plant for the testing of various coals from any location yielding technical data suitable for the design of commercially sized IPTACSS installations.

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## 4.7 SWEDISH STATE POWER BOARD, VALLINGBY, SWEDEN

KILBORN

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 22, 1985

Mr. Roy Carlson
Statens Vattenfallsverk
El-Och Varmeteknik
Konstruktionssektionen Forvarmeteknik
S-162 87 Vallingby
SWEDEN

Dear Roy:

It has been a long time since we met at the Coal Preparation Congress in Donetsk. I was unable to attend the conference in India, but I read with interest your paper on the cleaning of fine coals. I hope you will be able to attend the 10th Congress in Edmonton, Canada in 1986, which is now in an advanced stage of planning.

I am writing to ask if you can help me with regard to a project concerning the beneficiation of pulverized coal. Kilborn is just starting the development and design of a 5-ton per hour pilot plant on behalf of the Canadian Government's CANMET Coal Research Facility in Edmonton, for the 'deep cleaning' of fine coal. Basically, the coal will be pulverized (probably by wet ball milling) and subsequently cleaned to a low ash by a variety of test processes (oil agglomeration, froth flotation, high intensity magnetic separation, etc.). We are conducting a survey of pilot plants carrying out work in this area, and I would request any information you have available on the Swedish State Power Board's program on fines cleaning, particularly flowsheets, layouts and descriptions of your test facilities. I would also appreciate any information you might have available on the preparation of coals for the NYCOL and CARBOGEL processes.

With best regards, hoping to see you at the Congress next year.

Yours very truly,

KILBORN ENGINEERING (B. C.) LTD.

Tony Walters

A. D. Walters, P.Eng.,
Manager, Coal Preparation

ADW/mr

1985-12-17 BVV2-RCn/AJ-3783

Roy Carlson

Mr A.D. Walters, P. Eng.
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VANCOUVER, CANADA V6Z 2B7
Canada

RECEIVED
JAN 16 1986
Ans'd.

Dear Tony,

Thank you for your letter dated November 22, 1985. I hope I will be able to attend the congress in Edmonton but nothing is decided. It would be real nice to meet you and talk about coal preparation and memories from Donetsk.

Regarding your questions I am sorry to report that the Swedish State Power Board does not have any test facilities for coal preparation. All work on coal preparation is at present laid down. However, in the future I believe it will be of interest again. CARBOGEL does not have any facilities for coal preparation here. All Carbogel is manufactured at licenssees abroad. NYCOL and FLUIDCARBON do manufacture here in Sweden and are both using the flotation processes.

./. After I have contacted the three companies I have received the enclosed information from CARBOGEL only. I hope it is of some value to you. If you need more information from CARBOGEL they informe me that you can write to the following addresses:

Mr Eric Thomas
AB Carbogel
Box 16025
250 16 HELSINGBORG
Sweden

or

Mr Sven Andersson
Carbogel Canada Ltd
c/o Boliden Canada Ltd
P.O. Box 197
TORONTO 1, ONTARIO MK5 1H6
Canada

THE SWEDISH STATE POWER BOARD

Postal Address
S-162 87 VÄLLINGBY
SWEDEN

Head Office
Jämtlandsgatan 99

Telephone
08-739 5000

Telegram
Vattenfall

Telex
19653 SVTELVAS

My very best regards and hope to see you at the Congress.

Sincerely yours,

Statens Vattenfallsverk
Värmekraft

Roy Carlson

Roy Carlson

**FOSTER WHEELER**

# Production and Economics of a Beneficiated Coal Water Fuel Based on the Carbogel Process

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# PRODUCTION & ECONOMICS OF A BENEFICIATED COAL WATER FUEL BASED ON THE CARBOGEL PROCESS

1.0 INTRODUCTION

2.0 PRODUCTION PLANT DESCRIPTION

- 2.1 Block Flow Diagram
- 2.2 Production Facilities
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  - 2.2.3 Froth Flotation
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    - Storage & Loading
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- 2.4 Additives
- 2.5 Product Properties

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- 3.2 Production Plant
- 3.3 Commercial Demonstration

# ECONOMICS OF THE PREPARATION AND USE
# OF BENEFICIATED COAL WATER SLURRIES
# BASED ON THE CARBOGEL PROCESS

## 1.0 INTRODUCTION

On a Btu basis, coal is cheaper than oil or gas. This situation which has been traditional has maintained itself even in the face of recent declines in the price of oil. Although these price declines have eroded some of the cost differential, coal is still cheaper by several dollars per million Btu's.

- o Oil @ \$29/Bbl = \$4.80 per $10^6$ Btu
- o Coal @ \$50/Ton = \$2.50 per $10^6$ Btu

One of the new techniques for taking advantage of this favorable cost difference is through the use of coal water slurries. By properly combining a finely ground coal with water and suitable additives it is possible to produce a stable oil-like coal water fuel (CWF). Further, once the coal has been fine ground to produce the slurry it can be beneficiated at slight additional cost to produce a high quality fuel.

Often there is an initial concern that the presence of 20 to 30% water in the slurry will reduce the heating value due to vaporization of the water. In fact in combustion only about 4% of the available heat is lost to vaporization.

Some of the outstanding advantages of this new CWF are:

- o It is a lower priced fuel on the Btu basis
- o It is handled as a liquid similar to fuel oil
- o It is pumpable, storable, and atomizable.
- o It is substantially cleaner (lower ash and sulfur) than run of mine coal and in some instances, would meet requirements for a "compliance fuel".

## 2.0 PRODUCTION PLANT DESCRIPTION

### 2.1 BLOCK FLOW DIAGRAM

Figure 1 is a block flow diagram showing the principal elements in the Carbogel CWF process.

The basic process blocks are:

- Coal Receiving, Storage and Crushing
- Wet Grinding to proper size distribution
- Froth Flotation benefication for ash and sulfur removal
- Filtration and Dewatering
- Mixing
- Storage and Loading

These elements are further explained in the following section. These facilities are illustrated on tentative plot plans; Figure 2 and 3.

### 2.2 PRODUCTION FACILITIES

#### 2.2.1 Coal Receiving and Crushing

It has been assumed that coal for the "grassroots" plant would arrive by rail in a unit train from 70 to 100 cars, each containing 100 tons of run of mine coal, 2" x 0". These cars would have manually released doors for unloading through a grizzly to an undertrack hopper.

Coal from the hoppers is taken by feeders and conveyor belts to either a live storage pile or directly to the crusher tower. Once through the crusher where it is reduced to 3/4 x 0, it is put in silo storage awaiting subsequent transfer to the grinding mills.

For a "mine mouth washery" location, it has been assumed that the coal would be received directly via a conveyor belt and taken directly to the crusher tower.

Both the reject tailing steam and the fuel stream that exit the process are dewatered and the clear water recovered is recycled to the front end of the process.

### 2.2.5 Mixing

The filter cake of clean coal that is discharged from the filters is sent to a continuous intensive mixer where the stabilizing chemicals are added to produce the desired fuel characteristics.

Upon leaving the mixers the product fuel is pumped to storage for final loading and shipping or immediate use.

### 2.2.6 Support Facilities

Support facilities include storage, loading, buildings and utilities. Buildings and utilities are described in Paragraph 4.2.2 and are listed in Table I. Storage and loading is described below.

#### 2.2.6.1 Storage and Loading

On site storage in conventional vertical steel tanks is provided for 15 to 30 days of plant output. This large storage capacity assures continues supply of fuel to the user.

At the grassroots location, facilities are included for loading of railroad tank cars and river barges, the mine mouth location does not include barge facilities.

Additives for final slurry formulation are chosen from surface active water soluble dispersants, stabilizers, and possibly bacteriostats for long term storage ( > 6 months).

Normally the dispersants are added in amounts to a final concentration of 0.3 to 0.5% and other chemicals are used in concentrations below 0.1%.

The addition of these additives can effect the fuel behavior and must be carefully formulated and blended with ground coal of proper size distribution to achieve the desired final slurry properties. It is critical therefore for the user to carefully define and specify the product desired and to assure himself that the supplier has sufficient quality control awareness and capability to continuously manufacture an acceptable product.

## 2.5 PRODUCT PROPERTIES

Coal water fuels are pourable liquid mixtures of coal resembling No. 6 fuel oil in appearance. Viscosities and rheologies vary with coal loadings, particulate sizes and additive systems chosen. Normal utility boiler fuels display working viscosities in the 1000-1500 cp range at 50 to 100 $S^{-1}$ shear rate.

The rheologies of these liquids are non-Newtonian, increasingly so with increased coal loading. At very low to moderate shear, pseudoplasticity dominates (up to 400-500 $S^{-1}$). At very high shear, slight tendencies towards dilatant behavior are apparent, particularly with highly loaded slurries (above 75-80% solids). It is desirable for slurries to exhibit a slight initial shear stress before initiating flow (similar to a Bingham plastic). This initial resistance to deformation indicates a stable fuel formulation.

These slurries have been extensively tested to determine physical properties (most specifically their rheology and viscosity) and have been subject to successful test burns that evaluate atomization and combustion characteristics.

## 3.0 COMMERCIAL EXPERIENCE

### 3.1 PILOT PLANT

Carbogel CWF has been prepared in test quantities in a pilot plant. These quantities have been used in combustion, rheological, and transportation stability tests.

Overall approximately 50 tons have been produced in this facility.

### 3.2 PRODUCTION PLANT

As a next step in scaling up, an ore plant was converted to CWF manufacture. The plant was started on Harbor Seam coal from Nova Scotia and it operated at a rate of 5 to 10 tons/hour. By the end of 1982, approximately 8000 tons of various coals had been processed through this plant.

The CWF produced was used in a variety of test burns, rheological, pumping and transportation tests. All of the tests indicated that the material could be handled and burned utilizing fairly conventional equipment.

### 3.3 COMMERCIAL DEMONSTRATION

The first complete commercial demonstration program is currently underway in Nova Scotia Canada. The program starts with the production of coal water fuel using technology developed by A. B. Carbogel and continues through testing in commercial boilers. This fuel production plant, which will be producing in mid-1983, is part of the largest and most extensive testing to date using CWF's.

The project is sponsored by the Canadian government (Energy Mines and Resources Canada) and involves the Cape Breton Development Corporation the New Brunswick Electric Power Commission and the Nova Scotia Power Corporation.

## 4.0 ECONOMICS

Coal Water Fuels (CWF) offer the attraction of getting the low price of coal while simultaneously getting the ease of handling of oil.

Based on a Federal Energy Regulatory Commission report from the fall of 1982 an average delivered price of No. 6 oil was \$28.98 Bbl (\$4.83/$10^6$ Btu) and coal was \$49.72 Ton (\$2.49/$10^6$ Btu). This gives a differential of \$2.34/$10^6$ Btu in favor of coal; however if using CWF this cost differential is reduced somewhat reduced by the cost of producing the CWF.

Elements of the cost of producing a ton of CWF are the following:

- Capital Costs (Debt Service and Depreciation)
- Raw Materials (delivered Coal and Chemicals)
- Utilities (Power, Fuel Oil, Ash Disposal)
- Processing Cost (Operating Labor, Maintenance, Supervision, Overhead, etc.)

## 4.1 ASSUMPTIONS AND BASIS

### 4.1.1 Plant Size

Capital costs were estimated for two plant sizes having the following capacities.

2,750,000 tons/yr CWF
770,000 tons/yr CWF

### 4.1.2 Plant Locations

Grass Roots and Stand Alone

Two locations were chosen. One was a "grass roots stand alone" facility at a location approximately 500 miles from a mine and 100 miles from the market area. It would have an extensive rail siding to provide holding space for a unit train and also provisions for loading of rail cars and river barges with CWF.

### 4.1.4 Ash and Sulfur Removal

| | |
|---|---|
| Pyrite Removal | 80% |
| Ash Removal | 60% |
| Btu Recovery | 93% |

## 4.2 CAPITAL COST ESTIMATE

### 4.2.1 Plant Cost Summary

Summary of Conceptual Plant Cost
For Carbogel Slurry Plants

| – | Grass Roots | | Mine Mouth | |
|---|---|---|---|---|
| | 2,750,000 T/Yr | 770,000 T/Yr | 2,750,000 T/Yr | 770,000 T/Yr |
| Coal Handling | $14,800,000 | $12,000,000 | $ 7,800,000 | $ 6,000,000 |
| Slurry Production | 49,400,000 | 23,000,000 | 49,400,000 | 23,000,000 |
| Support Facilities | 42,800,000 | 23,000,000 | 23,800,000 | 15,000,000 |
| | $107,000,000 | $58,000,000 | $81,000,000 | $44,000,000 |

Details are shown in Table I.

### 4.2.2 Description of Facilities

The following utilities and facilities are required for the production plant; they are shown on the tentative plot plans.

Steam - 15,000 lb/hr steam generator - 90 psig steam for space heating, tracing and heating coils (Carbogel must be kept above 0°C.) Current projections foresee using the tailings from the froth flotation as fuel for a fluid bed boiler as an alternative steam supplier.

Water - City water available at $0.25 per 100 gal.

Air - Compressor in utility building to supply air at 90 psig for plant air and dry a small stream for instrument air.

## 4.4 UTILITY COST

### Power

Utility costs have been determined from plant scale operations and confirmed with equipment manufacturers information. The general relation is as follows:

$$\text{Utilities (\$/Ton)} = \left( \frac{259.13}{(\text{Tons/Yr})^{0.08}} \right) \times .05\ \$/\text{KWHR} + 0.32$$

This includes power for both the Slurry Production and Support Facilities.

The figure of $0.32 per ton accounts for plant fuel oil and miscellaneous utilities.

### Ash Disposal

To provide for Ash Disposal, it is proposed that ash and tailings from a "grass roots" plant would go to secure ponds which are built over membrane liners with drainage systems. Periodically, these would be dredged and the solid sent to a landfill. A cost of $15/ton of ash (dry basis) has been assigned to this in the production cost.

For a plant at the mine mouth only $5/ton (ash) has been included for the ash disposal.

## 4.5 PROCESSING COST

Processing costs are those charges for operating labor, supervision, maintenance, supplies, overhead and insurance. They are based on specified percentages of the plant payroll and the Total Plant Cost.

In the case of holding the plant constant and varying the construction cost we find the following results for a 2,750,000 T/Yr slurry plant at a mine mouth location.

| Plant Cost | Slurry Cost Change |
|---|---|
| $67,500,000 | Base |
| $81,000,000 | +1.6% |
| $97,200,000 | +3.6% |

Hence it is seen from the above that a large increase in cost of plant (+44%) produced only a 3.6% increase in the slurry cost.

The effect of coal price on production cost of fuel is shown in Figure 4. This illustrates the strong impact that the cost of coal has on the final coal water fuel.

# REFERENCES

(1) Coal Water Slurry Systems for Oil Design Power Plants EPRI FP-1164, R. D. Glenn, A. W. Rhodes.

(2) Clean Air and Coal Water Slurry - Leon Green - Mech. Eng., November, 1982, p. 38.

(3) Some Rheological Data and Atomization Behavior of CWM's Containing 68 to 83% Coal-AB Carbogel-L. Gillberg et. al.

(4) Proceedings of the Coal Water Fuel Technology Workshop, March 19 and 20, 1981 at Pittsburgh, Pa.
Sponsored by Pittsburgh Energy Technology Center COE Contract No. DE AC0276CH00016.

(5) Development of Cold Water Slurries as Boiler Fuel Atlantic Research Corp. - Henderson, Scheffee & McHale Coal Technology 81, Vol. I, Pg. 251.

(6) Direct Firing of Coal Water Slurries - State of the Art Brookhavan National Lab - Dr. P. Marnell Coal Technology 80, Vol. V, Pg. 485.

(7) Changing Times and Units to Fire Coal.
Foster Wheeler Corp. - Raskin & Freidrich
Coal Technology 80, Vol. IV, Pg. 501.

(8) Feasibilityof Power Plant Conversions to Slurries Richard C. Furman, Consulting Engineer Coal Technology81, Vol. V, Pg. 199.

(9) Combustion Tests of Coal-Water Slurry
Babcock & Wilcox Co.
EPRI CS-2287 March 1982

## Table 1
## Capital Cost Estimates
## (1982 East Coast Costs)

| | | Grass Roots Plant | | Mine Mouth Washery | |
|---|---|---|---|---|---|
| I. | Slurry Production | 2,750,000 T/yr Slurry | 770,000 T/yr Slurry | 2,750,000 T/yr Slurry | 770,000 T/yr Slurry |
| | Coal Handling | | | | |
| | Receiving & Storage | 7,000,000 | 6,000,000 | - | - |
| | Crushing & Storage | 7,800,000 | 6,000,000 | 7,800,000 | 6,000,000 |
| | | 14,800,000 | 12,000,000 | 7,800,000 | 6,000,000 |
| | Slurry Preparation | | | | |
| | Wet Grinding | 16,00,000 | 7,500,000 | 16,000,000 | 7,500,000 |
| | Froth Flotation | 13,400,000 | 6,250,000 | 13,400,000 | 6,250,000 |
| | Filtering & Dewatering | 12,500,000 | 5,750,000 | 12,500,000 | 5,750,000 |
| | Mixing | 13,750,000 | 6,500,000 | 6,500,000 | 6,500,000 |
| | | 49,400,000 | 23,000,000 | 49,400,000 | 23,000,000 |
| II. | Support Facilities | | | | |
| | Storage & Load Out | | | | |
| | Tank Car Loading | 450,000 | 300,000 | 450,000 | 300,000 |
| | Barge Facilities | 2,900,000 | 2,900,000 | - | - |
| | Day Tanks | 1,300,000 | 600,000 | 1,300,000 | 600,000 |
| | Storage Tanks | 13,750,000 | 6,500,000 | 6,500,000 | 6,500,000 |
| | | 18,400,000 | 10,300,000 | 8,250,000 | 7,400,0000 |
| (1) | Buildings | 14,000,000 | 6,500,000 | 11,550,000 | 5,100,000 |
| (2) | Utilities | 10,400,000 | 6,200,000 | 4,000,000 | 2,500,000 |
| | Total | 107,000,000 | 58,000,000 | 81,000,000 | 44,000,000 |

(1) Buildings include Administration, Maintenance, Gate/Change House Slurry Preparation, Laboratory, Boiler House & Substation.

(2) Utilities include Boiler, Utilities, Ash Handling Ponds, Waste Water Treatment, Sewer and Sanitary, Power Distribution, Roads and Parking, Piping and Firewater, Fencing, Railroad Siding and Site Preparation.

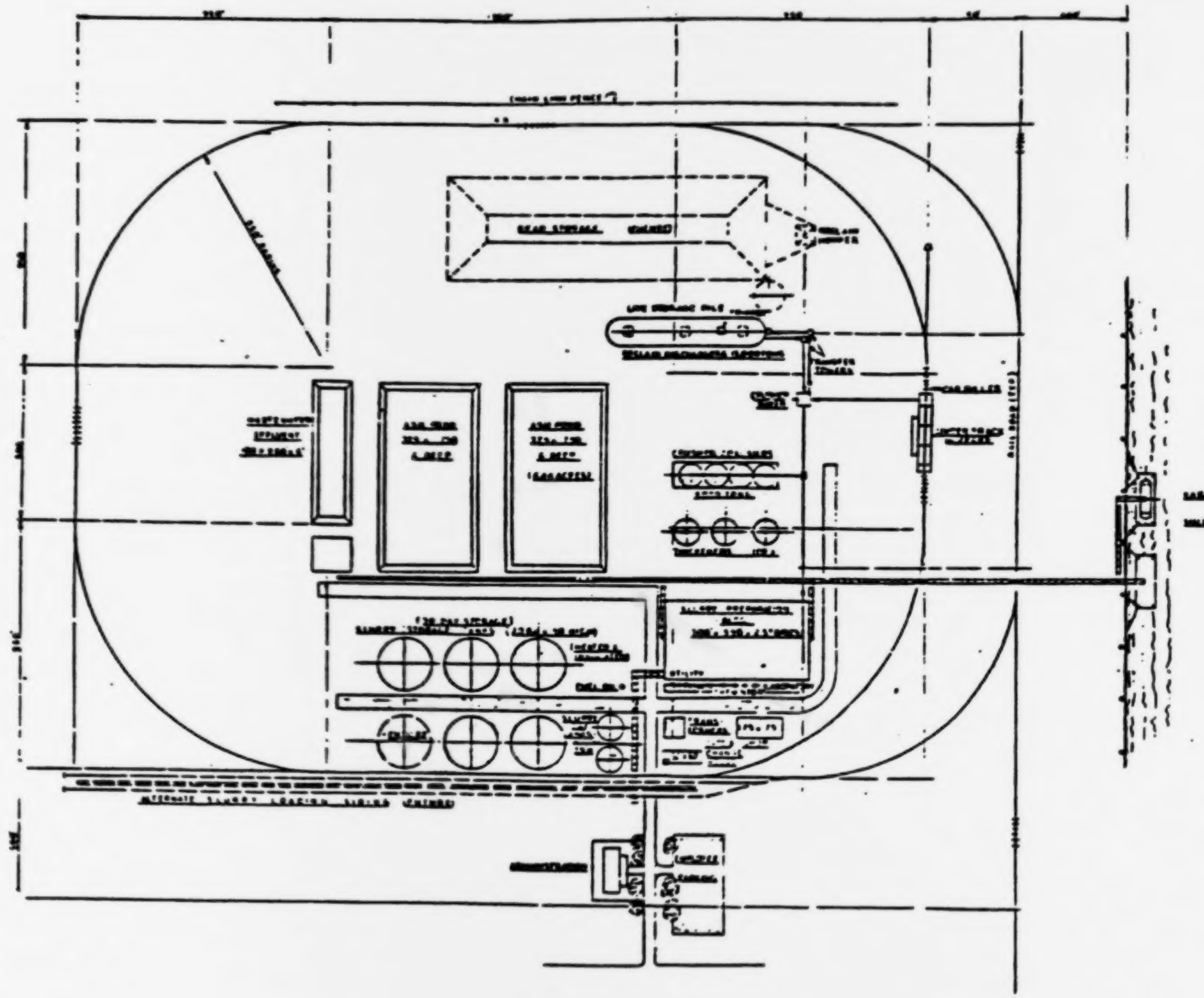
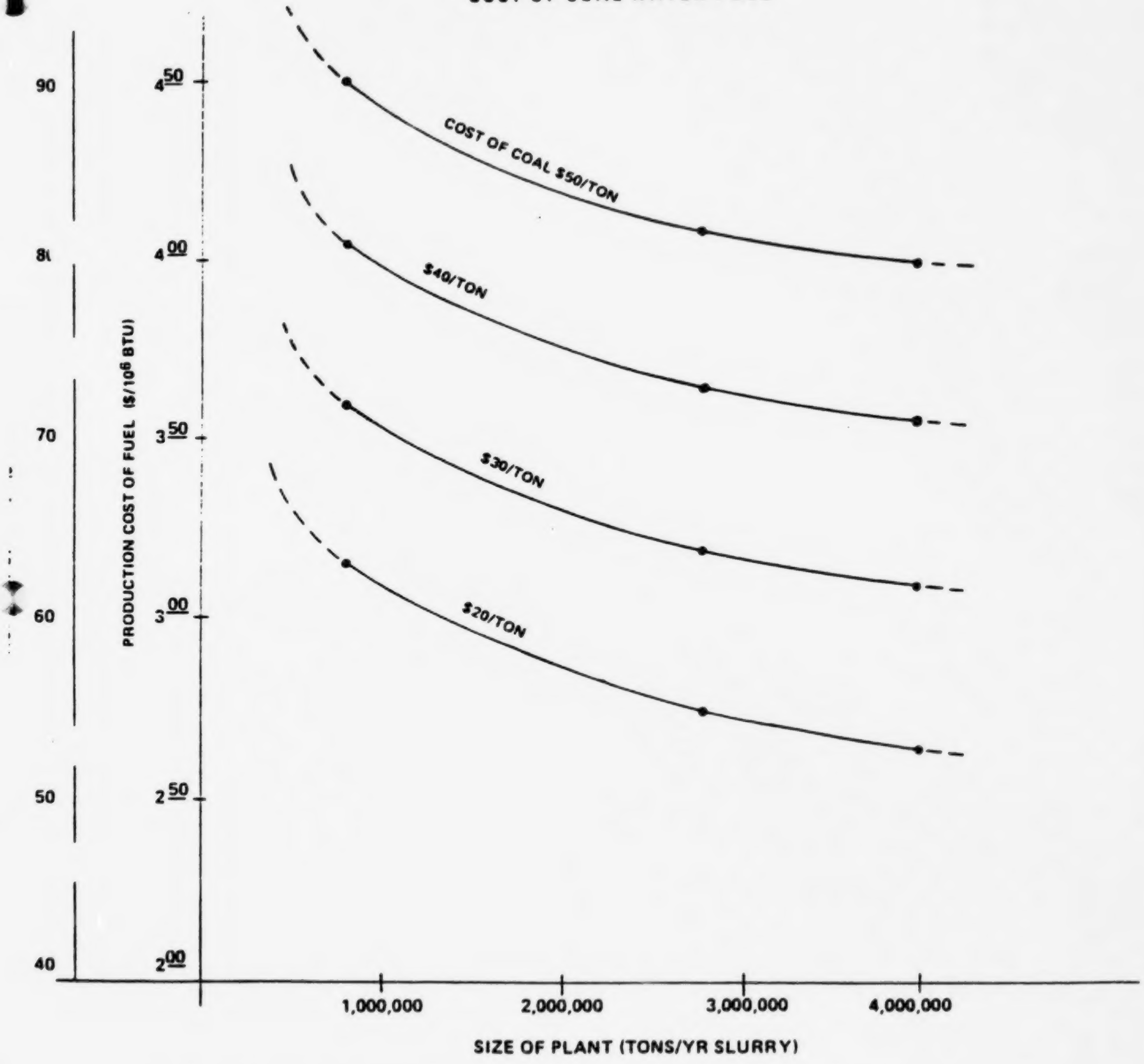


FIGURE 2

### EFFECT OF COAL PRICE
### ON
### COST OF COAL WATER FUEL



COST INCLUDES RAW MATERIALS' UTILITIES' PROCESSING COST DEBT SERVICE AND $20/TON SLURRY TRANSPORT

COAL WATER FUEL = 10,000 BTU/#
OIL = 6,000,000 BTU/Bbl.

FIGURE 4

## 4.8 ELECTRIC POWER DEVELOPMENT COMPANY (EPDC), TOKYO, JAPAN

## ELECTRIC POWER DEVELOPMENT COMPANY (EPDC)
## TOKYO, JAPAN

EPDC constructed a test pilot plant at the Wakamatsu Coal Utilization Technology Research Centre in 1982. Initially, research was carried out on coal-oil mixtures, but the main research area now is the milling, deep cleaning and transportation of coal-water fuels. The flowsheet of the pilot plant is shown in Figure 4.8-1.

The principal features of this slurry manufacturing plant is that slurry preparation is carried out in two stages by two wet ball mills. Compared to conventional one-stage slurry preparation, this system has certain advantages such as reduction of the expense of motive power in manufacturing and reduction of the amount of surfactant.

Deep cleaning of pulverized coal is carried out by froth flotation which was added to the plant in 1984, along with a slurry transportation test plant, storage test plant and shipping test plant.

The schedule for slurry testing is shown in Figure 4.8-2.

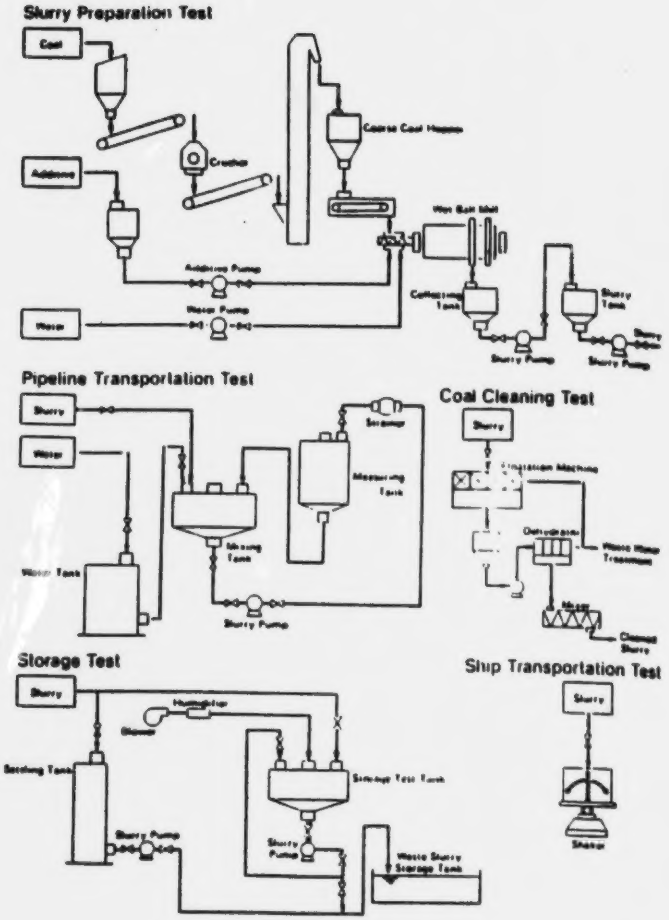
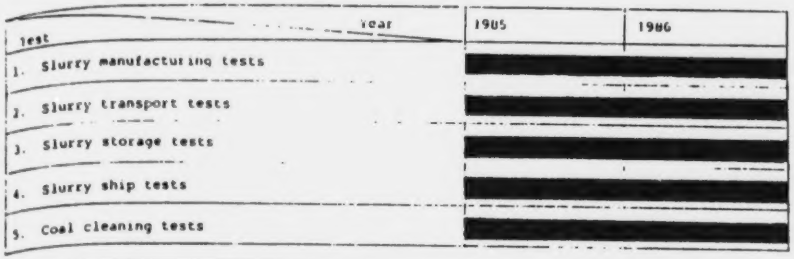

Slurry Preparation Test
Coal
Additive
Water
Crusher
Coarse Coal Hopper
Wet Ball Mill
Additive Pump
Water Pump
Collecting Tank
Slurry Tank
Slurry Pump
Slurry Pump
Pipeline Transportation Test
Slurry
Water
Strainer
Measuring Tank
Mixing Tank
Water Tank
Slurry Pump
Coal Cleaning Test
Slurry
Flotation Machine
Dehydrator
Waste Water Treatment
Mixer
Cleaned Slurry
Storage Test
Slurry
Humidifier
Blower
Settling Tank
Storage Test Tank
Slurry Pump
Slurry Pump
Waste Slurry Storage Tank
Ship Transportation Test
Slurry
Shaker

FIGURE 4.8-1: EPDC - PILOT PLANT FLOWSHEET



| Remarks | |
|---|---|
| 1 Slurry manufacturing tests | Relation between type of coal and slurry properties, and improvement of manufacturing process<br>Development of surfactant that will permit the amount added to be reduced, and improvement of manufacturing process<br>Determination of stability from additional energy applied by line mixer etc and slurry properties<br>Development of system to measure slurry properties on-line |
| 2 Slurry transport tests | Determination of pump piping performance and of corrosion and wear rates<br>Determination of slurry refluidization characteristics |
| 3 Slurry storage tests | Determination of changes in slurry properties when slurry is allowed to stand undisturbed.<br>Determination of changes in slurry properties when slurry is continuously agitated inside a tank |
| 4 Slurry ship tests | Determination of effect of vertical vibrations on slurry propurties during ship transport<br>Determination of effect of vertical motion on slurry properties during ship transport<br>Determination of effect of rolling motion on slurry properties during ship transport |
| 5 Coal cleaning tests | Determination of effectiveness of ash removal from different types of coal, and improvement of process<br>Development of method for making slurry from de-ashed coal, and determination of slurry properties<br>Development of technology for treating discharge water within the plant |

FIGURE 4.8-2: EPDC - PILOT PLANT TESTING SCHEDULE

## 4.9 MRDE, NATIONAL COAL BOARD, BRETBY, ENGLAND

KILBORN

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 26, 1985

Mr. Peter Cammack
Deputy Director, Coal Preparation
MRDE, Bretby
National Coal Board
Burton-on-Trent
Staffs DE 15 0QD
England

Dear Peter:

It is a long time since we last met; I think possibly at the Eighth Congress in Donetsk. I hope everything is well with you and that we will see you in Edmonton next year.

Following David Osborne's request for assistance with our magnetite project, I would like to ask for your further assistance. Kilborn Engineering have recently been awarded a contract by the Department of Energy, Mines and Resources for the development and design of a pilot plant for the 'deep cleaning' of pulverized coals (ie. to a very low ash or sulphur level). The plant will be an extension of the existing pilot plant at Edmonton, and will likely consist of a fine grinding section followed by such process options as froth flotation, oil agglomeration, high density magnetic separation, electrostatic separation, etc. The initial phase of the project will be a review of existing coal pilot plant installations and of 'deep cleaning' processes.

I am writing to request any current information or literature you may have on past or proposed work by MRDE at Bretby.

If you are able to provide assistance in this area, I would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B.C.) LTD.

Tony Walters.

**A.D. Walters**
Manager - Coal Preparation

ADW/rlk

**National Coal Board**
Ashby Road, Stanhope Bretby, Burton-on-Trent,
Staffs. DE15 0QD.
Telephone: Burton 0283 216161
Telegrams: Coalboard Burton
Telex: 341741 CBTD G
FAX: 0283 216161 Ext. 118

**NCB**

**Headquarters Technical Department**

Our Ref: 971

16 December 1985

Mr A D Walters
Manager - Coal Preparation
Kilborn Engineering (BC) Ltd
1380 Burrard St
Vancouver
Canada V6Z 2B7

RECEIVED
DEC [illegible]
Ans'd

Dear Tony

Thank you for your letter of 26 November, and it was good to hear from you again.

I am afraid not entirely clear of the particular type of information you required but as a start I am enclosing a recent state of the art review we have made on fine coal cleaning, also a booklet on Coal Preparation at Bretby which defines our current work programme. Quite a major part - perhaps 35% of our total effort is devoted to the cleaning of fines, and the associated disposal of tailings, and in the main our work is concentrated primarily on optimising the froth flotation system, and froth flotation system design combined with other processes, such as spirals, concentrating tables, and/or washing cyclones. Naturally the reduction of pyrite sulphur is of concern to us but we are very loathe to consider further crushing of coal to free mineral matter since this would inevitably worsen the problems we have on coal handlability. In some particular testwork carried out on electrostatic separators by Advanced Energy Dynamics for us, we had to conclude that this was not a technically viable process as far as UK coals were concerned, and additionally whilst we, the NCB, have not considered oil agglomeration we have been kept well informed by European partners on what they have been doing, and we also know of the work in India. To the best of knowledge oil agglomeration work has to a large extent stopped - mainly due to the excessive amount of oil used. The oil agglomerates are very small, they certainly do not alleviate coal handlability difficulties, there are technical problems still to be resolved on 'screening' the tailings after the oil process, and there are environmental issues - of smell, We have not considered chemical cleaning, and don't intend to. So you see this is predominantly why we are concentrating on froth flotation and composite system designs.

I do hope this information is a little towards what you require but please contact me again if I can be of any further help.

Kind regards.

Yours sincerely

Cammack

P Cammack
Deputy Chief Coal Preparation Engineer
Coal Preparation Division

## Summary of Comparative Position of Advanced Techniques

During the course of this review a large number of techniques have been studied. A summary of the overall findings is presented in the following table which should be read in conjunction with the following notes:

1. Application area: The judgement combined financial and technical relevance of a technique.

- Where "NOT DIRECTLY" comment is given, it is expected that the technique in question is not suitable as the major operation, but can be used for treatment of part of the stream or for reprocessing.

- The low ash sulphur p.f. fuel is delivered as dry product and lowering of sulphur emissions is achieved by a combination of increased CV and decreased sulphur content.

- To be considered as a possibility as an oil substitute the coal should contain <2% ash.

- For reprocessing of middlings, the dry magnetic separation seems particularly suitable because of its selectivity.

2. Extraction efficiency is generally assessed against density separation by float and sink method (F/S). Only pyritic sulphur can be affected by physical separation and hence the efficiency is expressed for this component.

3. Moisture content: A number of dry processes operate efficiently only when "stickiness" of the feed was eliminated by reducing the moisture content of the feed. The pre-drying would be carried out on large size particles before their comminution to the "preferred size" stated in column 6.

. Only relative cost projections would be attempted at present. For techniques aimed at production of oil substitute, the difference in the price of coal-oil can justify substantially more expensive treatment than for production of low sulphur pulverized fuel for conventional firing.

| | APPLICATION AREA | | | POTENTIAL EXTR. EFFICIENCY | | PREFERRED PARTICLE SIZE RANGE | FREE MOISTURE CONTENT % | | MAXIMUM REPORTED CAPACITY | COST RELATIVE TO CONVENTIONAL PROCESSING | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low Ash /S p.f. 1 | OIL SUBS-TITUTE 2 | REPRO CESSING OF MIDDLINGS 3 | ASH 4 | PYRITE 5 | mm 6 | FEED 7 | SOLID 8 | t/h 9 | CAPITAL 10 | RUNNING 11 | 12 |
| AQUEOUS MEDIUM<br>Dense medium for fines | yes | yes | yes | as F/S | | 0.5-0.15 | no limit | 20% | 45 | more | more | Full scale plant operating general problems with dewatering of fines. Useful option |
| Concentrating tables | yes | no | preferred | F/S | F/S | <10 | no limit | | 10-100 | more | more | Full scale plants operating. Useful option for further development. |
| Multi-stage froth flota- | yes | yes | yes | high | not known | <0.5 | no limit | 20% | | more | | General problems with dewatering of fines. Useful Option. |
| Oil Agglomeration | yes | yes | possible | high | not selective | <0.10 | no limit | 10-15% | | comparable | more | Excessive consumption of oil Cost comparisons with fuel oil needed. Pyrite removal not selective without surface modifications. |
| Chloro-fluoro carbon agglomeration | no | yes | no | very | high | <0.10 | no limit | 10% | 1 | N/A | N/A | Very early development. Cost comparisons with fuel oil needed. |
| IXNS | not directly | yes, as a stage | yes | 35% | 80% | <0.5 | no limit | 20% | 1 | comparable | less | Useful option. |
| Chemical Methods | possible | possible | no | high | high | <0.6 | no limit | | 1-10 | | more | Early stages of development. Only as an extension of physical deep cleaning. |

N.A. - Data not available.  F/S - Float and sink performance.

|  | APPLICATION AREA |  |  | [illegible] EXTR. EFFICIENCY |  | [illegible] PARTICLE SIZE RANGE | [illegible] MOISTURE CONTENT % |  | [illegible] REPORTED CAPACITY | [illegible] TO CONVENTIONAL PROCESSING |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Low Ash /S p.f. 1 | OIL SUBS-TITUTE ASH <2% 2 | REPRO CESSING OF MIDDLINGS 3 | ASH 4 | PYRITE 5 | mm 6 | FEED 7 | SOLID 8 | t/h 9 | CAPITAL 10 | RUNNING 11 | 12 |
| **DRY METHODS** |  |  |  |  |  |  |  |  |  |  |  |  |
| Pneumatic separators | not direct | not directly | yes | less than F/S |  | 0.5-0.1 | <5 | could be lower | 100 | less | less | Dust problem, low capital cost equipment, significant outstanding technical problems - NCB direct experience. Useful option. |
| Selective grinding | no | possible | possible | better than F/S |  | 40 | <5 | lower | 1 | N/A | N/A | Not conclusively demonstrated. |
| Electro-static |  |  | yes | as F/S |  | <1 |  | N/A | Lab | N/A | N/A | Bend scale tests only. |
| HGMS | yes | no | preferred | 20-50% | 80% | 1.0-0.1 | <5 | as feed | 1 | comparable | less | Limited experimental expereince used commercially for minerals' processing. Pre-sizing essential, combination with P.S. milling circuit successfully tested. Useful option. |
| Open Gradient | yes | no | preferred | F/S | F/S | broader than for HGMS | <5 | as feed | 0.3 | comparable | less | High throughput potential. |
| Magnetic enhancement | yes | no | preferred | 20% | 85% | <1? | 10% | probably dry | 1 | N/A | N/A | Could improve/simplify mag. sep. Early development. |
| **NON AQUEOUS** |  |  |  |  |  |  |  |  |  |  |  |  |
| Otisca | yes | no | yes | F/S | as F/S | 0.5 | 10% | dry | 100 | less | critically dependent on Freon recovery | Demonstration plant in operation. Excessive losses of medium. Current limits 0.5mm. Application made by FRG for ECSC support. Useful option. |

# ADVANCED COAL PREPARATION TECHNIQUES

## NCB/CEGB TASK GROUP III

## DRY MECHANICAL SEPARATION

### 1.1 Introduction

ry separation processes were introduced into coal cleaning more than a ndred years ago and were applied, at least in certain countries, on a ale commensurate with water based washing. Their popularity declined ly recently with the increased emphasis on the control of primary and econdary dust pollution and because the water based processes proved o be more efficient.

he main impetus for development and employment of pneumatic separation as shortage of water, difficulties with controlling waste water uality and the need to keep down the moisture content of the cleaned oal. This consideration applied particularly to smalls supplied as team coals in the northern part of the US where winter freezing emperatures called for handling essentially dry coal. (Nowadays, most f such supplies are thermally dried.)

n analogy to wet processes, most pneumatic processes exploit the ifferences in densities of the coal constituents. The basic theory is herefore common but the difference in the density (and viscosity) of oth media have many practical consequences.

his significance can be illustrated on the correlation between the ltimate falling velocity, particle size and density. A particle of a ensity $s_1$ falling in a medium of density $s_0$ will have the same ltimate falling velocity as another particle with density $s_2$ if their iameter $d_1$, $d_2$ were corresponding to a ratio

$$\frac{d_2}{d_1} = \frac{s_1 - s_0}{s_2 - s_0}$$

or pyrite ($s_1 = 5$) and coal ($s_2 = 1.3$) the ratio is $d_2/d_1 = 13$ for ater and 3.8 for air. It follows that if raw coal contained particles f the size range of up to 1:13 pyrite could be, theoretically, eparated from clean coal by elutriation only. For pneumatic eparation, the size range would have to be only 3.8, and taking into ccount the mixed nature of the mineral matter (average density 2.5) the size ratio should be less than 2. Feed for successful one-stage pneumatic separation must be therefore closely sized. Conversely particularly high efficiency can be achieved in two subsequent steps combining for instance a narrow range split according to falling velocity in aerodynamic classifiers followed by impact separation or sizing. Ross (1) suggested for the second step the use of a shallow inclined chute in which relatively smaller, dense, particle (or pyrite) would concentrate at the bottom.

### 1.2 Pneumatic Jigs and Air Tables

These devices using either pulsating or continuous current of air have been used on a commercial basis on a large scale. Chapman and Mott (2) cite, for instance, a construction of a dry coal cleaning plant in 1928 n the UK with a total capacity of 865 tons per hour. The same authors n their monography on coal cleaning discuss no less than nine ndustrial pneumatic jigs alone and devote a whole chapter to pneumatic ables.

ypically, a pneumatic jig consists of a trough fitted with a sieve or erforated deck supporting the coal particles. Air stream from a fan asses through a rotating valve creating pulses of a frequency of 400 o 500 per minute. The pulses cause stratification of the material and djustable partitions enable the products to be divided as required. uccessful separation was reported on material from millimetre size ange down to about 50 µ.

he decline of the more recent interest in commercial pneumatic eparators is illustrated by the fact that Khoury (3) in his survey of oal cleaning technology devotes to these machines only a short ection. In the US the percentage of coal cleaned by aerodynamic ethods (as part of all cleaned coal) fell from over 14% in 1942 to 4% n 1972.

modern 1000 t/h air table plant gives rise to about 400,000 m$^3$ of ust laden air per hour (approximately equivalent to the flue gas flow of 120 MW boiler). Because of the explosion risk associated with coal ust, extraction of the dust should be carried out only in mechanical cyclone) units combined with bag houses (i.e. electrostatic filters ust be avoided). However, closing the air loop could alleviate most of these problems.

In this context, it is also interesting to note that Battelle (4), in the latest environmental assessment of coal cleaning process proposes in one of the options to use air tables for cleaning fine and ultrafine middlings.

### 1.3 Direct Air Fluidisation in Pinched Sluice

Pinched sluice consisting of a shallow, tapered trough about 1.5 m long was provided with a porous plastic or sintered metal deck (Fig.1). The discharge end of the sluice was fitted with a splitter separating heavier and lighter constituents. Results (5) were reported on beneficiation on a number of ores and on one sample of coal, or discard, containing about 70% ash in feed.

Working with 75 cm long sluice and throughput of 740 kg/h (size range 3 x 0.5 mm) approximately 94% of the combustible matter was recovered in product with about 20% ash content in a single pass operation. The angle of slope of the sluice was 20° and fluidizing air velocity about 0.3 m/s. Further improvements were predicted with longer sluice or multiple passage. In the early seventies, NRDC granted a licence for an industrial version of this device to DRYFLO Separators Ltd., which has been taken over by an American company.

### 1.4 Heavy Media Fluid Bed Separators

Using finely ground heavy materials (e.g. ferrosilicon) it was possible to adjust the effective separation density of fluid bed devices in a wide range of specific gravities (e.s. 1-4). The porous base of the separator was provided with a vibrator which transported the heavy sink fractions away from the light fraction discharge chute. Such an rangement was apparently suitable for processing of coal particles in he range 0.5 to 0.075 mm.

SL also developed a rotating annular bed separator typically operating ith radial acceleration of 9-10 g. It was reported (6) that up to 70% pyrite was extracted from pulverised coal (6.25 mm x 0) with 99% ecovery of the combustibles. A laboratory device (Fig.2) of 63 mm ameter with a half cone angle of 6° worked with a throughput of about 5 kg coal $h^{-1}$.

### 1.5 Selective Grinding

nother concept for separation of mineral matter from coal attempts to xploit differences in grindability of coal constituents. Even ndividual size fractions of run of mine product show marked ifferences in ash content, as is illustrated in Table 1 for three ritish coals.

he Energy Recycling Corporation of Australia applied in the later eventies for a patent for a selective comminution device (7) using ases with high velocity flow. Jet energy mills producing very finely round materials utilizing fluid vortex motion have been introduced arlier (8) but it was claimed that in this new device the difference n hardness of coal constituents will produce variation in sizes ufficient for efficient separation. It was claimed that solid articles were separated by a shock of amplitude sufficient to release onds between the (heterogeneous) particles and to reduce the softer articles but not to break the harder particles.

number of reports (9,10) appeared about the involvement of the Lower olorado River Authority in a contract for development and large scale pplication of the clean coal product. At least two companies' names, beside the original Energy Recycling Corporation, have been associated ith the project, the Kintyre Enterprises of Sydney and Accelerated Elements Co., California.

CERL has tried over the years to find out more about the projects directly from the manufacturers and the utility involved but without much success. According to the latest private communications, the actual extent of previous effort is uncertain. Serious doubt was also expressed about the reliability of the available technical data.

### 1.6 Electrostatic Separators

The separation of fine coal and shale via differences in induced electrostatic charges was examined by the NCB in 1955. It was found however that the process was very critical to moisture, throughput rates had to be very low, and narrow size ranges 8 - 30 mesh and 60 - 120 mesh for example were essential. Assessments of cost showed electrostatic cleaning to be totally uneconomic in 1955, but at that time no examinations were made on the removal of sulphur (pyrites).

The concept was later experimentally reassessed by the U.S. Bureau of Mines (Abel et al 1973). Fine, dry coal was at first classified in a pneumatic centrifugal separator producing middlings with enriched content of pyrites. Electrostatic separation was applied to this

| Particle Size | Markham | | Silverdale | | Treeton | |
|---|---|---|---|---|---|---|
| | % wt | % ash | % wt | % ash | % wt | % ash |
| mm | | | | | | |
| + 100 mm | | | | | 0.7 | 55.8 |
| 100 - 50 mm | | | | | 3.9 | 39.6 |
| 50 - 25 mm | 37.4 | 40.8 | 36.6 | 25.5 | 14.5 | 36.9 |
| 25 - 12.5 mm | | | | | 20.6 | 37.0 |
| 12.5 - 6.3 mm | 20.6 | 31.3 | 25.4 | 28.8 | 14.4 | 37.8 |
| 6.3 - 3.2 mm | 15.7 | 34.7 | 10.8 | 32.9 | 16.7 | 41.8 |
| 3.2 - 0.5 mm | 19.8 | 36.9 | 18.0 | 38.6 | 19.8 | 43.4 |
| - 0.5 mm | 6.5 | 40.8 | 9.2 | 44.7 | 9.4 | 50.7 |
| TOTAL | 100.0 | 37.1 | 100.0 | 31.3 | 100.0 | 40.7 |

TABLE 1 Variation of Ash Content with Size Fraction

eam apparently with an efficiency comparable to that achievable in at and sink tests with 1.6 specific gravity. Some further elopment of this process, which has the potential for selective raction of pyrites, has been more recently reported by Inculet 80) and Carta (1982).

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FIG.1 PINCHED SLUICE PNEUMATIC SEPARATOR

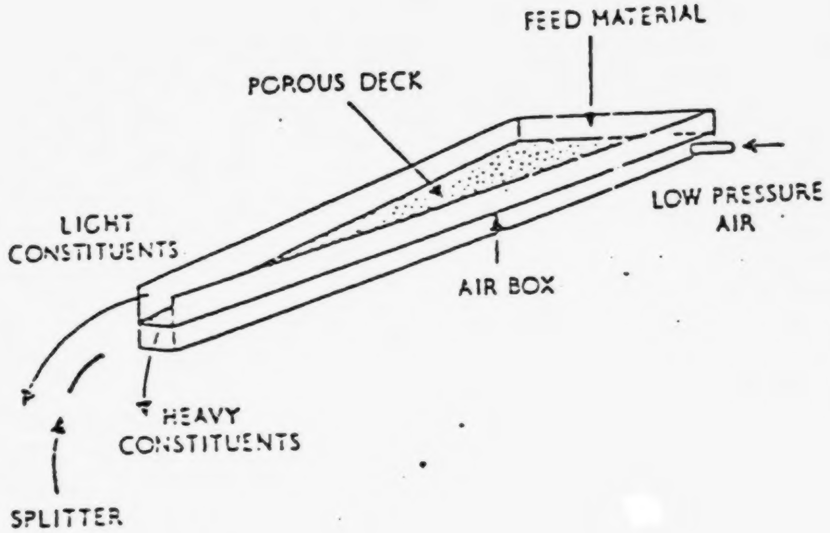
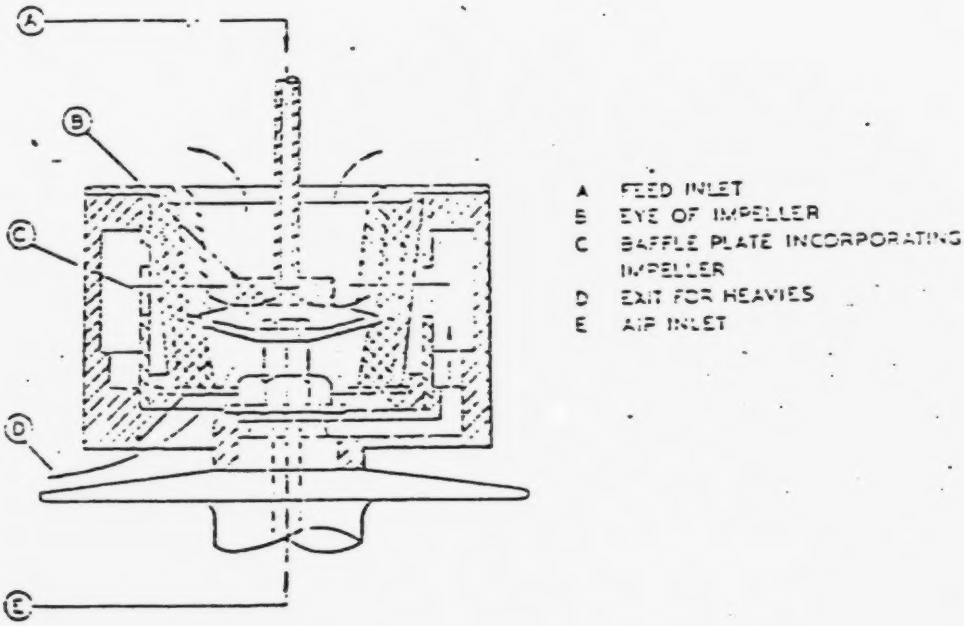

FEED MATERIAL
POROUS DECK
LOW PRESSURE AIR
LIGHT CONSTITUENTS
AIR BOX
HEAVY CONSTITUENTS
SPLITTER

FIG. 2 W.S.L. ROTORY FLUDISED BED SEPARATOR


A
B
C
D
E
A FEED INLET
B EYE OF IMPELLER
C BAFFLE PLATE INCORPORATING IMPELLER
D EXIT FOR HEAVIES
E AIR INLET

## MAGNETIC SEPARATION

### 2.1 Introduction

gnetic separation of iron based materials from a mixture has been mon industrial practice for many years. Such separators use rmanent or electromagnets to remove large ferromagnetic impurities om non-magnetic products. Although these machines are adequate for rge magnetic objects, they do not work well for small (500 µm) weakly gnetic particles. A separator capable of handling such materials was veloped in the early seventies. It consisted of finely divided steel bres placed on a high background magnetic field, see Fig.1. The bres (known as the matrix) occupy only about 5% of the field volume d produce very high magnetic gradients (0.1 T/µm). With such high eld gradients small weakly magnetic particles can be captured as the rce on a particle moving through the separator is proportional to th the field and field gradient. That is:

$$F_m = V \mu_o \chi \underline{H} \nabla \underline{H}$$

here V is the volume of the particle

$\chi$ is the particles magnetic susceptibiity

$\mu_o$ is the permeability of free space

H is the magnetic field.

particle in a magnetic separator will experience a magnetic force nding to attract it to the fibres and various other forces tending to ep it within the fluid stream. If the magnetic force is sufficient overcome the opposing forces, then the particle will be captured. he motion of the particle in the filter has been shown (1,2) to depend $u_m/u$ where $u_m$ is the so-called magnetic velocity and is oportional to $\chi H \nabla H$, and u is the velocity of fluid stream. To move a particle $u_m/u$ must be of the order of unity. The magnetic usceptibility of the particle to be removed is of primary importance nd for mineral impurities in United Kingdom coals $\chi$ is $5\text{-}10 \times 10^{-6}$ emu $g^{-1}$(3). This is relatively small and necessitates the use of high agnetic fields and gradients to achieve good removal efficiencies. In ractice, two types of separator have sufficient magnetic field radients, the Kolm-Marston type high gradient magnetic separator HGMS) and the open gradient superconducting separator (4,5).

he coal feed supplied to the separator contains the organic mineral-ree and non-pyritic coal. It also contains magnetically polarizable ree particles of mineral matter and of inorganic sulphur which can be rapped relatively easily at capture sites in the magnetic filter. urthermore, it contains middlings comprising particles containing both rganic coal and unliberated paramagnetic inorganic materials. Some of hese middlings are trapped on the matrix, thus causing an important raction of the organic coal to be included in the rejects, with a onsequent reduction in the thermal (Btu) value of the product. herefore the size to which the coal is ground and consequent degree of iberation of the mineral matter is of crucial importance to the verall performance of the magnetic separator.

## 2.2 Dry High Gradient Magnetic Separation (HGMS) of Coal

udies (6,7) passing unclassified coal through a HGMS have generally own that the performance is poor. This is because gas-particulate xtures suffer from the problem of 'stickiness' which is a direct nsequence of the moisture content of the particles. Particles aller than 10 µm are the primary cause and little can be done except ther drying or removal of the fines. The speculation is that the tickiness' tends to make the coal and pyrite particles adhere gether. This combined with high Stokes settling velocity, severe essure drop requirements, poor flow distribution around the matrix d electrostatic interactions severely hinders the magnetic separation ocess.

cently, work by Hise and co-workers (8,9,10) at Oak Ridge National boratory (ORNL) on the separation of carefully dried and classified als with the fines removed has proved very encouraging with the ssibility of pilot plant operation in the near future. The asurements using an HGMS have shown that for liberated minerals in y crushed coal, sulphur and ash are reduced with comparable ficiency to that of the specific gravity process for a size fraction +100 mesh (707-149 µm).

e most successful mode of operation was to gravity feed the coal with ry low transport velocity through the magnetic separator. These erating conditions are well suited to continuous HGMS using a rousel type machine. The results of trials using just such a machine ve been reported by Hise et al (10) and demonstrate that both sulphur d ash can be reduced by amounts similar to that obtained using a tch HGMS for processing rates up to 1 ton per hour.

rr et al (11) have shown that a high gradient magnetic separator can successfully combined with a roller mill classifier to give total lphur reduction between 20 and 40 wt. %.

th appropriate classification dry high gradient magnetic separation an reduce pyritic sulphur by 80 wt. % for certain coals. The Btu ecovery is typically 90%.

## 2.3 Open Gradient Magnetic Separation

In this type of magnetic separator, the high magnetic field radients are produced by superconducting coils and not magnetizable ibres placed in a background field. The active area of the magnetic eparator is therefore completely free of any matrix material. A umber of authors (5,12,13,14) have published work using this type of eparator. Hise (5,14) has produced the most promising results using a usp mode solenoid. It was designed to have a field times field radient product of the same order as the HGMS. Diamagnetic particles re pushed to the centre of the solenoid and therefore the separation s essentially diamagnetic. Using a circular ring feeder with flow ates up to 300 kg hr$^{-1}$ the results from the cusp mode superconducting GMS compare well with HGMS on similarly classified coals. This echnique offers the possibility of true continuous dry processing of al, however, the main problem at present is the limited throughput. hile the magnets may function satisfactorily, problems are more likely n the supporting plant for circulating the very low temperature fluid essary to maintain superconductivity, particularly if these are ated in an industrial atmosphere. Reliability is vital. The CEGB talled a super conducting motor of about 2,300 KW on a main culating water pump drive at Fawley Power Station in the late 0's. This was removed because of the unreliability of the auxiliary ipment.

influence of strong magnetic fields on personnel needs sideration. Will access be allowed during operation? Is it essary?

## 2.4 Wet High Gradient Magnetic Separation (HGMS) of Coal

demineralization of coal using HGMS on water/coal slurries is siderably easier than dry separation because of the reduced electro-tic forces and better flow distribution. A number of studies 7,14,15) have shown that HGMS is effective in reducing the weight centage of total sulphur, ash and inorganic sulphur by as much as 35 and 80 wt.% respectively while achieving a maximum recovery of wt.%. Slurry concentration up to 30 wt.% coal seems to have little ect on the overall efficiency and significantly, coal of fine size ctions can be used (e.g. 90% of the coal less than 74 μm) with all fines retained. Recycling of the product has been shown by Lin et (15) to reduce the ash content by 64 wt.% and the inorganic sulphur 76 wt.%.

ecent and comprehensive analysis of wet coal cleaning has been lished by EPRI (7). The primary objective of the work was to form an engineering assessment of the feasibility of magnetic coal aning for the electric utilities. Of the four projects undertaken part of the study, two used HGMS directly on water-coal slurries; a Magnetics Inc. used an iron cased solenoid for tests on five tern USA bituminous coals and Magnetic Co. of America tested two ilar coals with a superconducting HGMS.

Sala tests were performed on a laboratory scale HGMS (fig 3) (Sala Model 15-20) with a 10 cm bore and a pilot plant scale continuous ousel. Both could be operated at fields up to 1.7T. The coals were rried at concentrations ranging from 0 to 15 wt.% coal and processed velocities from 0.5 to 4 cm $s^{-1}$. The optimum grind for the coal essary to liberate the mineral matter depends on the size tribution of the mineral matter within the coal, therefore Sala ted a number of different grinds from 60 percent minus 200 mesh (-74 to 90 percent minus 200 mesh. As expected, the finer the coal nd, the greater the sulphur removal. Typical inverse relationship ween the produce grade and recovery was reported. Overall formance of the batch HGMS was comparable with the figures above.

ample of Delmont mine coal cleaned at 1.6 specific gravity prior to nding was processed using the continuous HGMS carousel at a field of T and a flow of 1 cm $s^{-1}$. The results showed that reduction in al sulphur from 3.84 to 1.33 wt.% and in ash from 11.1 to 4.5 wt.% ld be achieved. Fig. 4 shows a continuous carousel HGMS. The basic rating principle of this separator is identical to that described the solenoid high gradient magnetic separator. ever, the capture matrix revolves through the magnetic field rather n remaining stationary inside the solenoid electromagnet. When a tion of the matrix is within a magnetic head (an individual ectromagnet assembly), high magnetic field gradients are induced ound its surfaces and magnetic particles are captured. As soon as matrix moves out of a magnetic head, the induced magnetic gradients pidly decay and captured magnetics are flushed from the matrix. In der to remove mechanically entrained non-magnetic particles, a rinse applied before the matrix exits a magnetic head, i.e. while the gnetic capture forces are still present. Clear or clarified water usually, used for both matrix flushing and rinsing. Matrix volution rate is of the order of 1 rpm.

MCA work investigated Old Ben and Delmont Mine coal using a super-ducting HGMS capable of producing fields up to 5.0T. The results e in broad agreement with the previous study but with higher total phur reduction of up to 55 wt.% for clean coal yields of 60%.

ng mineral processing magnetic separation technology proposals based the EPRI study (7) have been made for a carousel HGMS processing up 200 tons per hour. However, the scheme has not been implemented cause of the high cost of dewatering finely ground coal.

ercial high intensity magnetic separators in the U.K. are ufactured by Boxmag-Rapid Ltd., which has supplied a number of these hines for extraction of paramagnetic minerals. The currently gest single unit can process about 40 t/h of feed (on dry basis). preferred particle size is approximately 1 mm to 10 μm. The quoted dget price is £300,000, power consumption 50 kW at equilibrium. Data coal preparation efficiency are not yet available.

## 2.5 Magnetic Enhancement

veral studies (16,17) have shown that under the appropriate nditions, the conversion of iron pyrite to a more magnetic phase is ssible. The problem is that temperatures in excess of 300°C are eded. For iron pyrite in coal considerable energy would be wasted in ating the coal and also decomposition of the coal may occur.

overcome these problems, Ergun and Bean (18) suggested and demonrated the selective heating of iron pyrite by microwaves but coal-on pyrite mixtures gave inconclusive results. Recent work by Fanslow al (19) has shown that the pyrite and mineral matter in coal are ated 2 to 3 times faster than the carbonaceous coal at a microwave quency of 245 GHz. Selective microwave heating, however, has yet to ow that it can significantly increase the magnetic susceptibility of on pyrite particles in coal and thereby increase their magnetic paration efficiency.

en Research Incorporated (20) have invented a process which selecvely enhances the pyrite susceptibility by chemical means. It is own as the 'Magnex' process and involves heating the pulverized coal 170°C and then subjecting it to iron pentacarbonyl vapour. The iron selectively deposited on the mineral matter which can then be ocessed using low or medium gradient magnetic separators. Reductions up to 85 wt.% of the pyritic sulphur and 26 wt.% of the ash have en reported (7) for a Pennsylvania coal using an induced-magnetic ll separator. Although the process has the advantage of working at w temperature and pressure, the toxicity and process consumption (32 /ton of coal) or iron pentacarbonyl are distinct problems. At esent, the process is still under development.

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FIG. 3 HIGH GRADIENT MAGNETIC FILTER

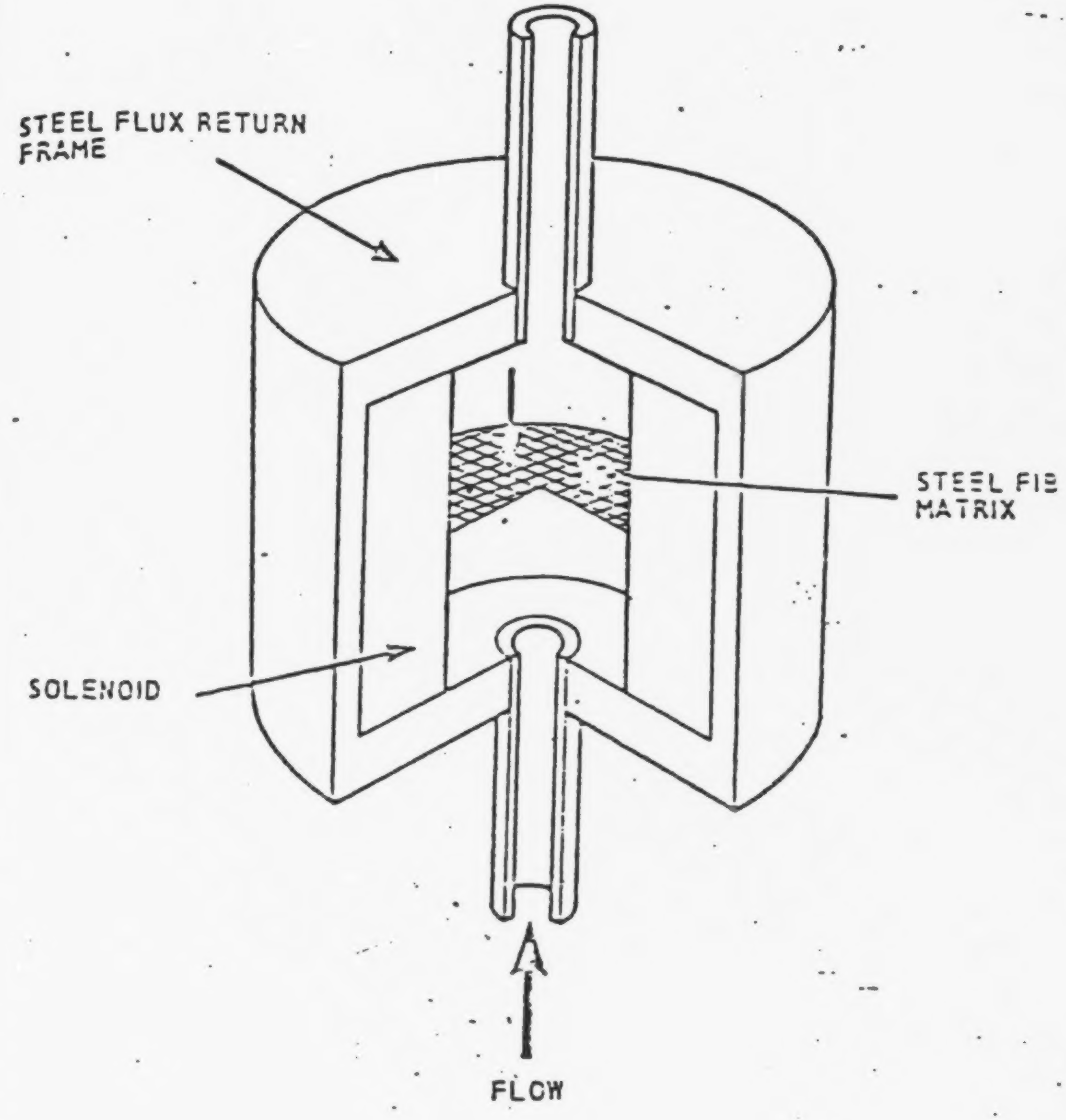
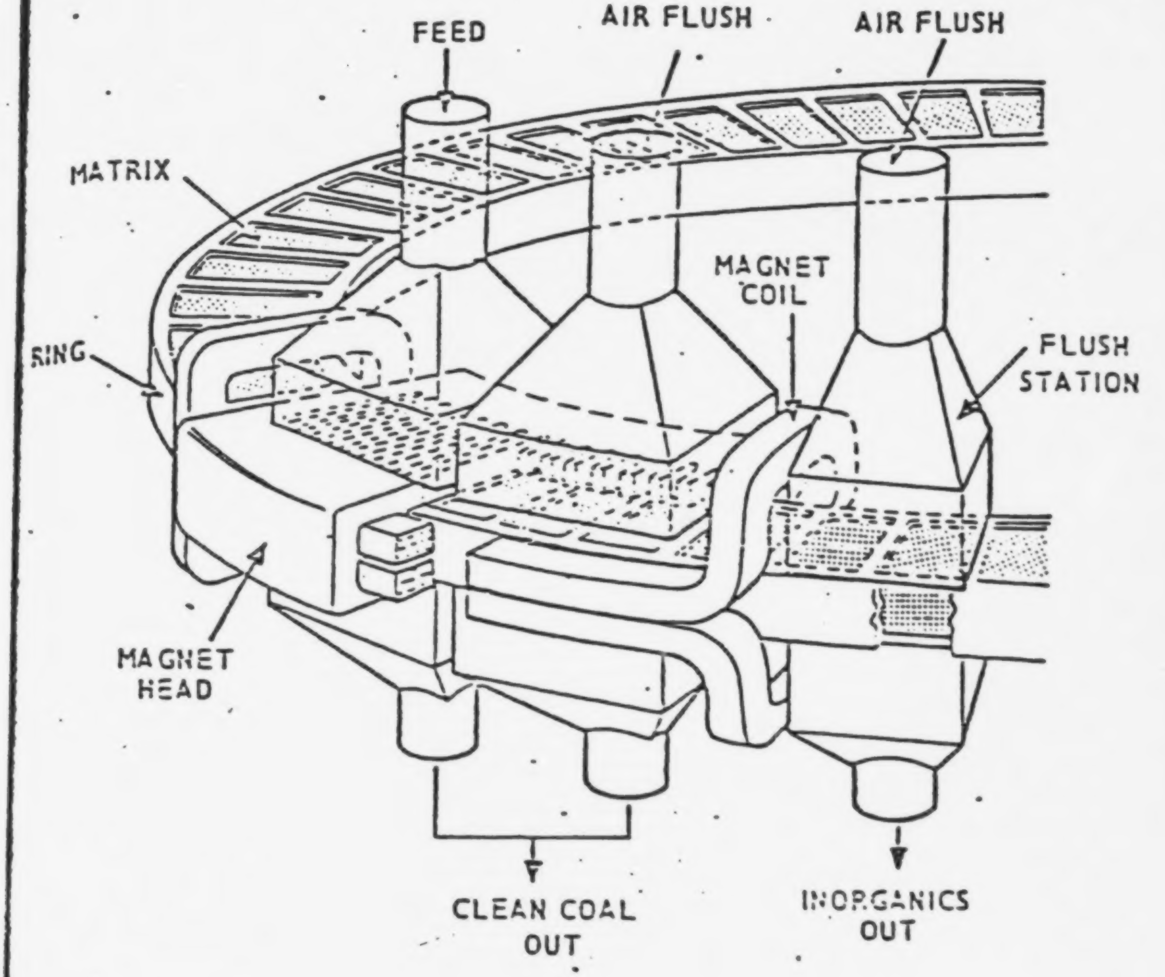

STEEL FLUX RETURN FRAME
STEEL FIB MATRIX
SOLENOID
FLOW

FIG.4 WET HGMS COAL SEPARATION


FEED
AIR FLUSH
AIR FLUSH
MATRIX
MAGNET COIL
RING
FLUSH STATION
MAGNET HEAD
CLEAN COAL OUT
INORGANICS OUT

## 3. OTISCA PROCESS

### 3.1 Introduction

e process, developed and designed by OTISCA Industries, uses a eparation liquid based on Freon ($CCl_3F$) with specific gravity about .5 and boiling point 24°C. Coal, shale and pyrites are separated on e basis of their relative densities. In addition, any process water s effectively transferred from the raw coal into the mineral matter nd the recovered clean coal is substantially dry and therefore of igher calorific value. This is of significant value in the reduction f sulphur emissions on a thermal basis. Evaporation and condensation eat exchanger equipment is required as ancilliary plant for the ecovery of the Freon separating liquid.

: a test plant in the United States, it was shown that the accuracy of paration for material of 28 mesh size was comparable with that of arser 6 mm size treated in a conventional dense medium bath. In that espect therefore there is improved performance with the Otisca ocess. However, 28 mesh appears to be the lower size limit of eaning in order for displacement velocities not to affect the paration.

### 3.2 The Demonstration Plant

e American Electric Power Co (AEP) built and commissioned the largest onstration plant so far (capacity 145 t/h) based on the OTISCA hnology. The design was derived from tests carried out on a pilot ant in Florence, Pennsylvania, with capacity about 7t r.o.m. per ur. Originally, it was intended to build an integrated plant loiting also chemical comminution by ammonia as both techniques were eered at the Syracuse University, New York. This original plant d to be rejected as, apparently, the respective inventors could not ree on commercial aspects of such a project.

the AEP plant, raw coal is fed through an inclined feeder into a lindrical vessel (so called conditioner) in which the coal is roughly mixed with about 15% by weight of the parting liquid. An specified additive is used to ensure wetting of the solids. During s conditioning, lasting about one minute, most of the free moisture the coal is apparently replaced by the Freon liquid. Water is fectively transferred into the mineral matter with which it is also ally recovered and the cleaned coal is produced substantially dry. separation of the coal from the mineral matter takes place in a angular vessel about 6m long and 3m deep filled with 50 t of Freon. lassified r.o.m. coal, consisting of particles below about 1 cm eter, is fed into the vessel. The separated float and sink ~~as~~ products are racted by conveyor collectors discharging the solids into a separate where the parting liquid is first drained and then evaporated. evaporation is achieved by heating the coal to 30-40°C using rect, rotating jacket disc heaters which at the same time propel products to a discharge point. The extracted vapour of Freon, and some air is compressed to 250 psig, the Freon is condensed in er cooled heat exchangers and the remaining gas phase passed through ar-filled absorber.

### 3.3 Process Potential

In comparison with conventional, water based coal washing plant, this process claims a number of advantages. The major one is the ability to treat unclassified r.o.m., including fines about 28 mesh, in one operation with, hopefully, high sharpness of separation reflecting the apparent density of each solid particle. Considering the design throughput, the plant is also remarkably compact, includes only three operations and it is clean with low noise levels.

So far, the full production capacity has been achieved only for short periods (hours). It appears that the main separation vessel does not provide sufficient time for complete density separation of the small particles but AEP* is satisfied with the overall cleaning efficiency, so, e.g. for a particular Muskingum coal, the ash level is reduced from 3 to 12% and total sulphur from 6 to 4%.

It has been suggested that the capital cost should be about half that of a conventional plant with comparable treatment of fines. The major single component of the projected operating cost is the loss of the separating liquid (priced at $700 per tonne). The "acceptable" loss would be about 1 kg/t r.o.m. but so far the performance of the demonstration plant was much worse, about 10 kg. The possible environmental consequences of a further substantial source of atmospheric contamination by Freons have not been yet assessed. During the 70's, total global production of CFCl was about 300 kt/a of which 50% was used an aerosol propellants. Coal processing by OTISCA could therefore significantly affect the existing balance. The loss of Freon could also present a hazard in the plant area as it can collect in lower levels and reduce oxygen content.

The NCB have supported Bergbauforchung West Germany, in an application to the ECSC for a project to evaluate the Ostica process for cleaning and de-sulphurising European coals. At the present, this project has been given a priority 2 rating, for which insufficient funds are available to allow the research to proceed. However, if more financial resources are provided by the Community, the project will begin.

## 4. WATER BASED PROCESSES

### 4.1 Dense Medium Cleaning of Fines (Minus 500 Microns)

The smallest size of coal treated by dense medium processes using suspensions of finely ground magnetite in water is conventionally 500 microns. In operating coal preparation plants positive steps are taken to remove all fines below this size by wet screening and to a level such that at worse only 3/4% pass forward into the washing process. This technique is adopted for two reasons. Firstly, with all the magnetite medium solids being significantly finer than 500 microns, the recovery of a major part of the magnetite by screening is relatively easy; and secondly, but of equal importance, carry over of coal and shale fines into the separating medium creates problems of viscosity, so causing inefficient separation of the minus 3 mm sizes of the raw coal feed even in centrifugal separators operating in the region of 10-12 g. Conventionally, 500 μm - 0 raw coal is cleaned by the froth flotation process.

rimarily, to reduce the amount of material passing to expensive froth lotation and filtration equipment but, also as a means of separating 500 µm - 0 fines at pre-selected relative densities, attempts have been ade in a number of countries to treat this material by dense medium. he Dutch State Mines was probably the first organisation to examine his technique, and produced basic flow diagrams in 1957, to which esign it is understood two plants in Belgium were subsequently built. ther countries have also carried out pilot plant studies, South Africa nd the USA in particular, and the National Coal Board has undertaken aboratory trials.

e evidence from all the work is that dense medium processing of fines nus 500 µm size in centrifugal processors can produce good parations down to about 150 µm size. As found in work at MRDE wever, it is essential to have inlet pressures to the separators up three times higher than those used in conventional cyclones in order overcome the effects of viscosity, the solids concentration in the ed should be significantly lower, and also that a much finer sizing the magnetite medium solids is required for optimum performance.

treating raw coal minus 500 µm by dense medium, a completely fferent system of medium recovery circuit design has to be adopted, ereby coal and shale solids after processing are separated from the gnetite medium solids by permanent magnetic drum separators. To nform to the operating criteria for the drum separators, particularly terms of the concentration of feed solids, and the ratio of non-gnetic to magnetic solids, large numbers of the machines are cessary for efficient recovery and separation of the magnetite lids. Even so, because of the superfine sizing of the magnetite dium solids (60% minus 10 µm), a significant amount is lost from the rcuit both on the coal and shale products, and from the magnetic drum parators.

eration of a pilot plant in Pretoria South Africa is reported to have solved the circuit design and reduced the magnetite losses to ceptable levels such that a plant for 45 ton/h of raw coal feed was be built in 1980. There have been no reports however of the continued mercial operation of this plant.

large 1200 ton/h Homer City Plant in Pennsylvania USA also included se medium cleaning of minus 500 µm fines, but although this plant been built for about 3-4 years, there is no real evidence that ues of circuit design have been completely resolved to a sound nomic commercial level.

se medium cleaning of fines below 500 µm is technically possible, even though there is little or no published data on performance er in the laboratory or from commercial plant of the effect on phur reduction, the fact that generally sulphur in many coals is nning to be released at sizes below 500 µm, also that in dense um processors the relative density of separation can be set at any el to give acceptable cleaning to 150 µm size, present opportunity for positive reductions in the pyritic sulphur ent of coal. Nevertheless, at the present, and until more is known t the magnetite medium recovery circuit design in continuous ation, also of any subsequent problems created to recover and ter minus 150 µm superfines for enviromental reasons, the economic e medium cleaning of fines below 500 µm has still to be regarded as r development.

### 4.2 Multiple Stage Flotation

Single stage froth flotation for the separation of coal from high ash shale in sizes minus 500 µm, is not an effective means of reducing the absolute sulphur content of coal for although pyrites may be liberated in these sizes, it is usually always carried in suspension with the clean coal product. Additionally, for the UK, and similarly also for other countries, the sulphur content of the clean coal from single stage flotation in many cases may be higher than that of the raw coal feed because of concentration of the organic sulphur. However, as with any other preparation process used for the beneficiation of clean coal product ash content, by increasing thermal value, single stage flotation does indirectly effectively cause a reduction in $SO_2$ emission when the coal is burnt, and this reduction can be as high as 38 - 45%.

Multiple stage flotation in which the coal concentrates from one stage are further processed in two or more stages, can produce improved separation of pyrites particularly if special reagents are used and flotation conditions modified, either to selectively depress or alternatively float the pyrites particles. Multi-stage flotation also significantly reduces the ash content of the clean coal concentrates, and increases calorific value, which produces further improvement in the sulphur emission levels on combustion. At the present, most examinations of multiple stage flotation have been carried out in laboratories from which it appears greatest benefits are obtained with coals of much higher sulphur levels, such as 3-4%, as found in the East Coast of the United States.

More research is required therefore to investigate the difference in surface chemical properties of fine coal and pyrites to lead to the development of more selective reagents to preferentially depress either the coal or the pyrites, and provide a better basis for multi-stage flotation. Proving trials will then be necessary on a large commercial scale to ensure that continuous use of the new special reagents does not 'poison' the coal preparation plant circuit, nor affect the performance of other processes and finally does not cause environmental problems.

### 4.3 Oil Agglomeration Process

The process is based on the difference in surface wetting behaviour of mineral matter and coal, i.e. exploiting the same physical properties as froth flotation. Coal particles are dispersed in a water-oil mixture, the oil preferentially adheres to the hydrophobic coal particles and the ash stays dispersed in water. The suspension is subject to vigorous mixing which helps to agglomerate the fine coal particles which on impact adhere together with oil forming the necessary bridging bond.

Conventionally, this principle has been employed to clean fine coal (less than 0.5 mm). There has been little work of the effect of oil agglomeration as a means of reducing the sulphur content. As with froth flotation, the similar surface properties of coal and pyrite hinder the prospects of selective extraction (ref.1.2).

Some researchers have reported a degree of success from using chemical or bacterial pretreatment (2.3.4.) to preconvert the pyrites surfaces iron oxides and soluble sulphates which are hydrophilic. The restigations are however at bench scale, and importantly pretreatment imes of up to 3 days appear to be necessary.

e type of oil used is important since the cheaper and heavier fuel ils usually contain appreciably higher sulphur than UK coals.

| | |
|---|---|
| Gas Oil | 0.6 % S |
| Light Fuel oil | 2.7 % S |
| Middle Fuel oil | 3.0 % S |
| Heavy Fuel oil | 3.3 % S |

ven the calorific value of oil added does not compensate to lower the erall SOx emission when the agglomerated coal is burnt. With the glomeration process requiring sometimes in excess of 10-12 % oil, here are strong doubts if it will even be used for coal-shale eparations. The process also suffered from mechanical difficulties, rticularly blinding of screens, and only a few plants are now perating in the world. Some installations commissioned have now eased to operate, and about 10/12 years ago, examinations of the vertol process in the North East of England as a means of reducing lphur in coking coals, were similarly abandoned. The oil glomeration process is not considered therefore with any real pectations to specifically reduce the sulphur content of coal.

e main interest in the updated version of this process stems from its tential to handle even very fine particles, perhaps well below 10 µm. grinding to such a small top size, the coal constituents are iberated as discreet particles and can be, in principle, separated. A ead in this direction has been taken by the National Research Council f Canada.

e pilot plant operated by Ontario Hydro has a capacity of about 4 t/h d has been reported to produce coal with 1-2% ash. It includes a ill with fixed grinding surfaces (SZEGO type) and several mixing tanks ot exceeding about 2 $m^3$ in volume each. The separation of the coal glomerate on a rotary 72 mesh sieve was very impressive, reducing ater content of the clean product to about 30%. Further mechanical ewatering, by centrifuging, can achieve about 10-15% moisture content. n order to facilitate recovery of the agglomeration oil and to ease andling the 30% moisture product is pelletized using asphalt as a inder. Several dryers have been tested for the oil recovery using lue gas or superheated steam as alternative carriers.

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typical slurry contains 15-20% solids and 1-2% of oil. However, the il to coal ratio might rise up to 1:2. As now envisaged, the system as high energy consumption due to heat needed for oil recovery (up to 7% of the coal heat content). Even with 90% oil recovery, the dditional cost of the agglomeration oil is too high at about 3.3 /tonne. The shortcomings are well illustrated by the projected perating cost. The basic unit of 100 t/h would cost about $8.5M and a inimum loss of oil is expected to be about 1.5% of the weight of coal. t would be possible to operate without oil recovery (saving on energy nd asphalt items) but the oil penalty would almost double the perating cost (Ref.5).

eferences

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)  J.H.Walsh, "Removal of Pyrite from Cape Breton Coals for tallurgical Processes", 9th Commonwealth Min and Metals Congress, 69 (p.143).

G.P.MASOLSITES, "Process for Agglomerating Coal", U.S.P. 282,004/1981.

)  J.BETTELHEIM, CERL Memorandum TPRD/L/CH 0050/M82.

### 4.4 Agglomeration with Chlorofluorocarbons

is process exploits the same phenomena as the oil agglomeration ocess but promises improved coal cleaning performance and better covery of the agglomerating media.

on the addition of small concentrations of a chlorofluorcarbon to a lute coal/water slurry, the media collects the carbon particles into ssive agglomerates which permits their separation across a sieve bend the like. Essentially, the coal is separated completely from the ter phase with its included mineral matter. The only moisture tained by the coal/agglomerant phase is there as individual droplets trapped in the very hydrophobic slurry. These droplets can be most adily removed by mechanical compression to a moisture content below wt.% moisture based on dry coal. The agglomerants are then exposed an evaporator and the complete recovery of the agglomerant as plained in the Media Process. The products retain less than 150 ppm the agglomerant.

en applied to coal particles ground to less than 20 μm, results for ur American coals indicated final ash content between 0.3 to 1%.

eference

.V.KELLER, Jr., Conference Presentation University of Alabama, "The nsolidation and Dewatering of Fine Particles", August 10-12, 1982.

### 4.5 Concentrating Tables

e concentrating table for coal cleaning is a development of the old tablished table used extensively in mineral dressing practices. mally, the coal size treated is 10 mm - 0, and separation is based differences in relative density. The heavy density material is ided by riffles fixed to the table away from the lighter density terial which flows over and across the riffles assisted by the wash ter. Pyritic sulphur being of approximately 5.0 relative density can separated well along the riffles and away from both the clean coal the shale, and improved separating precision can be obtained by imising operating conditions with restrictions in size range treated plications in conventional coal-shale separations have been hindered, wever, by the large number of machines required occupying a large oor space for a relatively small tonnage treated. Multideck units ch with individual drives and adjustments have overcome this problem o some extent, but to date the process has not been automatically ntrolled and intense manual supervision has been required for best rformance. The broad based band of operation of this technique, ssibly enhanced by control based on colorimetric monitoring of the rites, makes further development worth consideration.

## . COAL CLEANING BY CHEMICAL METHODS

like coal cleaning by physical techniques, chemical treatment has the tential to remove all the pyritic inorganic sulphur, and a major part the organic sulphur. The principal techniques favoured by Research ntres mainly in the United Stated, involve oxidation (air, oxygen, d chlorine), and displacement (calcium, potassium and sodium droxides) reactions. Coal for chemical treatment has to be of fine ze minus (600 μm) to speed the reaction time. Even so, in some cases ntact times up to 3 hours are necessary. In some cases severe aching conditions of pressure and temperature, to remove a higher oportion of the organic sulphur, have led to a decrease in the heat lue due to loss of carbon and hydrogen. Usually there is also preciable further reduction in particle size by chemical treatment.

me of the chemical coal cleaning developments being considered have en on-going for more than 10 years, very few have reached pilot plant age, and it is the opinion of the International Energy Agency (ICT S/TR.15) that few of the processes are really well understood. wever, apart from reducing sulphur, chemical treatment of coal also moves mineral matter and trace elements, and offers additional tential therefore to produce coal for coal/oil or coal/water mixture mbustion as a direct substitute for oil.

## . MICROBIOLOGICAL METHODS

Selective removal of pyrite from coal in the presence of ater and oxygen is achieved by acidophilic bacteria, namely errobacillus ferroxidants, which oxidise pyrite to ferric sulphate and lphuric acid. The process, naturally occurring during weathering of al, is promoted by particle size reduction and control of reaction nditions. Typically for coal with a top size of about 100 μm in lute water suspensions and pH 2.5-4.2 about 80% pyrite removal has en reported in 3 to 4 days. The disposal of the acidic waste liquor epresents a serious environmental problem.

The selectivity, and potentially favourable operating costs, ake the concept attractive and recently new proposals for development ere received from UK universities. It would be also possible to nsider microbiologically induced pyrite surface conversions as means or enhancement, e.g. of magnetic properties.

-

PPENDIX/A.22

## 4.10 B. C. RESEARCH, VANCOUVER

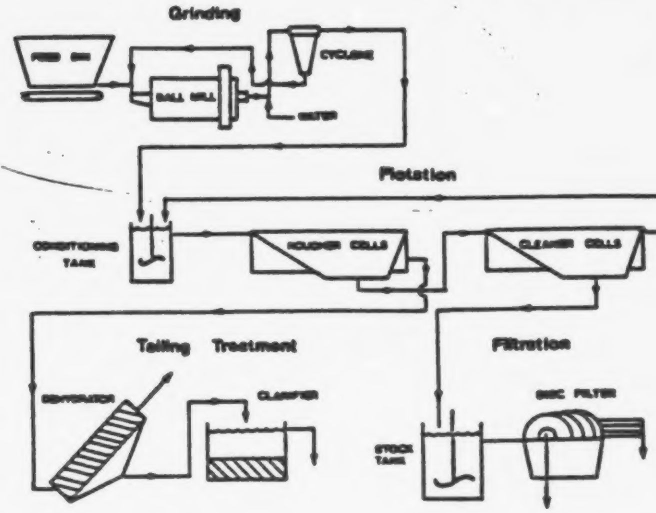
# B. C. RESEARCH

B. C. Research is situated on the U.B.C. Campus although it operates quite independently. It recently purchased the ESSO Fine Coal Cleaning Plant and trans-shipped it from Calgary to Vancouver. Major components of the plant include:

- A 2 $m^3$ raw coal bin and variable speed belt feeder.
- 1 m x 2 m ball mill with a charge of steel balls, in closed circuit with two 75 mm diameter classifying hydrocyclones.
- Conditioning tanks with 5 HP drives and reagent feeders.
- 10 Denver 0.34 $m^3$ sub 'A' flotation cells, installed as two banks (1 x 6 cells, 1 x 4 cells).
- A vacuum disc filter (1.2 m diameter x 4 discs).
- A tailings thickener/holding tank complete with flocculant addition unit.
- A 'Dehydrator' unit for tailings dewatering.

The accompanying photographs illustrate the plant layout.

Figure 1 : Esso Coal Beneficiation Plant Flowsheet


Grinding
FEED BIN
BALL MILL
CYCLONE
WATER
Flotation
CONDITIONING TANK
ROUGHER CELLS
CLEANER CELLS
Tailing Treatment
DEWATERER
CLARIFIER
Filtration
STOCK TANK
DISC FILTER

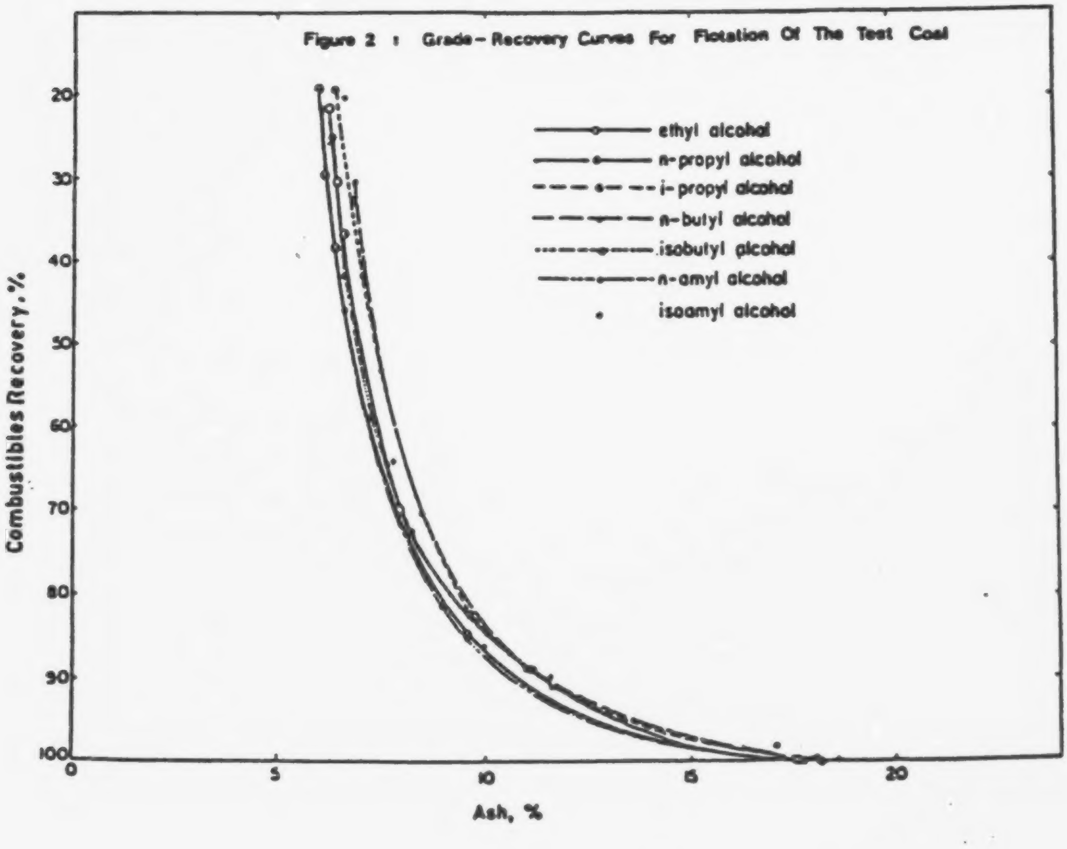


Figure 2 : Grade-Recovery Curves For Flotation Of The Test Coal

optimized to specific coals and market conditions.

## TEST MATERIALS AND METHODS

Coal samples for beneficiation tests were selected to represent types of low grade (i.e. high-ash) product or waste streams available in economically significant quantities. Origins and analyses of test coal feeds are presented in Table I.

Bulk coal samples of 25 - 50 tonnes were trucked from the mine, custom crushed to <8 mm at an off-site crushing plant and then transhipped to the pilot plant located adjacent to B.C. Research in Vancouver, B.C.

The coal beneficiation pilot plant flowsheet is shown in Figure 1.

Major pilot plant components include:

- a 2m$^3$ raw coal bin and variable speed belt feeder,
- 1m x 2m ball mill with a seasoned charge of steel balls, in closed circuit with two 75 mm diameter classifying hydrocyclones,
- conditioning tanks with 5 hp drives and reagent feeders,
- ten Denver 0.34 m$^3$ sub "A" flotation cells, installed as two banks (1 x 6 cells, 1 x 4 cells),
- a vacuum disc filter (1.2m dia. x 4 disc),
- a tailing thickener/holding tank c/w flocculant addition unit,
- a "Dehydrator" unit (1) for tailing dewatering.

Auxiliary equipment includes a 12.5m$^3$/min diesel powered air compressor for cell aeration, and slurry storage tanks.

Bulk coal samples received by truck are dumped to paved ground storage, with tarpaulin coverage in wet weather. Coal is reclaimed by a 0.5m$^3$ front end loader for transfer to the raw coal feed bin.

Clean coal bulk product (filter cake) is collected in ~0.4 m$^3$ poly lined boxes and tailing solids in disposal bins.

TABLE I DESCRIPTION OF COAL SAMPLES

| SAMPLE NO. | DESCRIPTION | ASH (wt %) |
|---|---|---|
| 1 | Fine Raw Coal (100% <6 mm) | 22.0 |
| 2 | Fine Raw Coal (100% <6 mm) | 26.0 |
| 3 | Weathered Raw Coal | 26.5 |
| 4 | Coarse Jig Reject | 27.5 |

## RESULTS AND DISCUSSION

### GRINDING/CLASSIFICATION CIRCUIT

The grinding circuit operating parameters for crushed coal feed (8 mm x 0) were generally as follows:

| | |
|---|---|
| Mill feed rate | 400 - 600 kg/hr. |
| Mill discharge density | 50 - 60% solids by weight |
| Cyclone feed pressure | + 124 KPa |
| Cyclone overflow | 10 - 14% solids by weight |
| Power consumption | ~10 kwh per tonne |

The product (cyclone overflow) particle size ranged from 65% to 90% passing 75 μm screen size, and was controlled within this range by cyclone feed sump dilution water. Under such operating conditions, recirculation load (cyclone underflow) varied in the range of 300-600% of mill feed rate. Due to the fineness of grind involved in this process, particle size analyses down to the 10 μm range would be required to compute true recirculation load in this grinding circuit. Lacking routine size analyses below 53 μm, no attempts were made to determine optimum recirculation load and classification efficiency. Since it was not possible to vary mill feed rate beyond 600 kg/h, the effects of mill feed rate on classification efficiency were not determined.

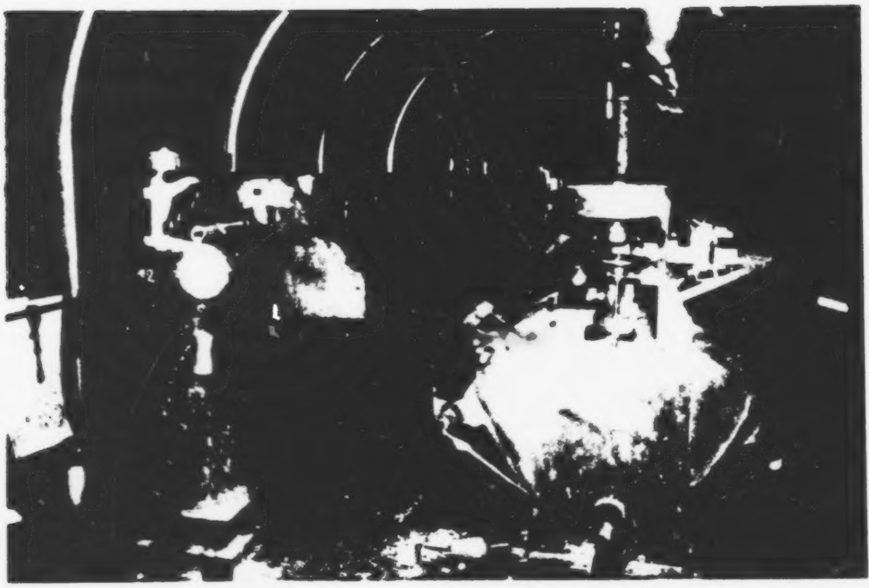
In general, the wet grinding/classification system operated satisfactorily and with good control.

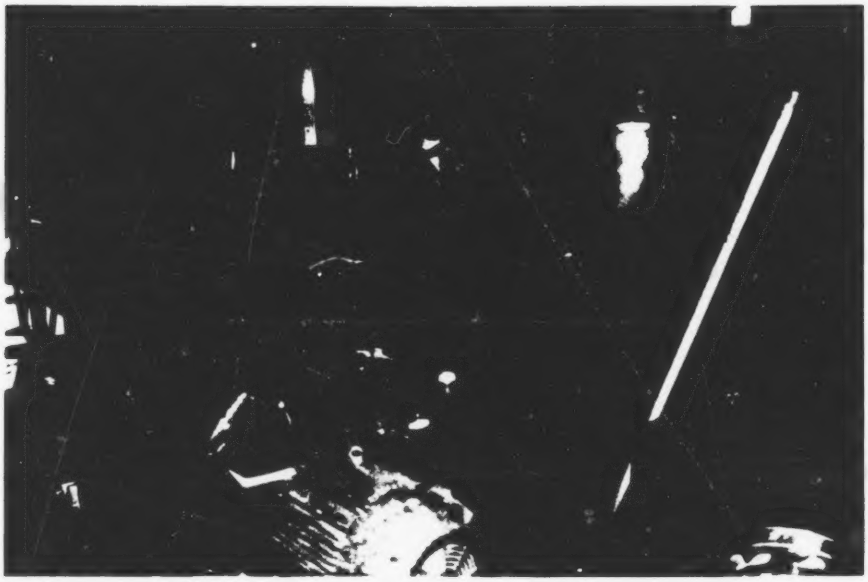
### FLOTATION

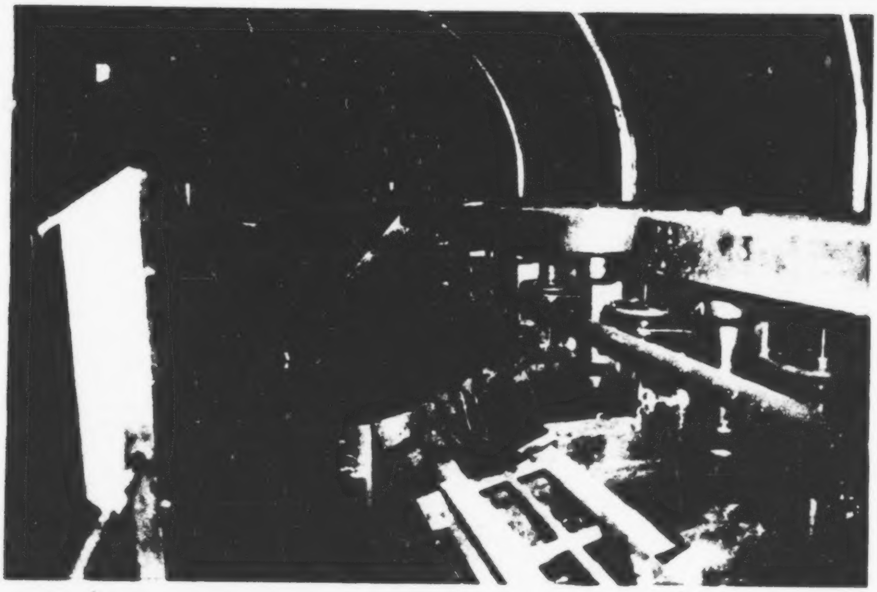
Previously reported laboratory data (2) indicated that use of lower alcohol frothers without any hydrocarbon collector can give both high selectivity and recovery in flotation of some finely ground coals. Summarized results presented in Figure 2 indicate the range of grade-recovery possibilities for the coal tested.

In the current study, isopropanol (IPA) was used for its high selectivity in the rougher cells of rougher-scavenger flotation and the cleaner cells of rougher-cleaner flotation. Methyl isobutyl carbinol (MIBC) was used for scavenging and in the rougher cells in rougher-cleaner operation. In these applications the more tenacious (and less selective) action of MIBC was acceptable due to either subsequent cleaning or the very dilute pulp in scavenger cells.

Previous work on similar rank coals from south-east B.C. (3) indicated that the limit of upgrading by spherical agglomeration is in the 6-8% ash range even with (economically prohibitive) grinding to <10 μm. Thus it appears that flotation under the identified conditions (Figure 2) can offer comparable







## 4.11 BHP CENTRAL RESEARCH LABORATORIES, WALLSEND, NEW SOUTH WALES, AUSTRALIA

## BHP CENTRAL RESEARCH LABORATORIES
## WALLSEND, NEW SOUTH WALES, AUSTRALIA

Pilot plant facilities have been installed in conjunction with BP Australia for research into oil agglomeration and pipeline transportation. The Integrated Pipeline Transportation and Coal Separation System (IPTACSS) is a new concept in the handling, cleaning, preparation, storage and transportation of coals from coal mines to steelworks, coke ovens, power stations and coal conversion plants.

Having developed the concept over the last 4 years with the aid of a 50 millimetre diameter pipeline pilot plant, a pilot demonstration experimental plant capable of handling approximately 30 tonnes per hour of raw coal has been installed. It incorporates features developed by BP Australia relating to hydrocarbon recovery. The pilot plant, fully developed, will include a raw coal stockpiling area to feed the plant, and consists of dumping facilities, crushing, grinding, coal slurrying, hydrocarbon injection equipment, pipeline loop, hydrocarbon recovery equipment, storage and blending ponds, dewatering equipment, water clarification ponds and clean agglomerated coal product loading bins.

Another area of research at BP Australia is a pilot scale column flotation plant at the Central Research Laboratory.

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 26, 1985

Mr. Stuart K. Nicol
Minerals Research Manager
BHP Central Research Laboratories
P.O. Box 188
Wallsend, NSW 2287
Australia

Dear Stuart:

It is a long time since we met; I think the last time was at the Eighth Coal Preparation Congress at Donetsk. I understand you were at the New Hampshire meeting which I had planned to attend but had to cancel at the last minute.

Following David Osborne's request for assistance with our magnetite project, I would like to ask for your further assistance. Kilborn has recently been awarded a contract by the Department of Engergy, Mines and Resources for the development and design of a pilot plant for the 'deep cleaning' of pulverized coals (i.e. to a very low ash or sulphur level). The plant will be an extension of the existing pilot plant at Edmonton, and will likely consist of a fine grinding section followed by such process options as froth flotation, oil agglomeration, high density magnetic separation, electrostatic separation, etc. The initial phase of the project will be a review of existing coal pilot plant installations and research programs.

I am writing to request any current non-proprietary information you may have on work carried out by BHP in the area of 'deep cleaning'.

If you are able to provide any assistance in this area, we would be most grateful indeed.

Yours truly,

KILBORN ENGINEERING (B.C.) LTD.

Tony Walters

A.D. Walters
Manager - Coal Preparation

ADW/rlk

## 4.12 UNITED COAL COMPANY
## BRISTOL, VIRGINIA

## UNITED COAL COMPANY - BRISTOL, VIRGINIA

United Coal Company is a very progressive and research-oriented firm, operating in Kentucky and South West Virginia. Over the last few years they have built up an impressive research facility at Bristol. It has almost exclusively been funded by contract research work for the Department of Energy. A. D. Walters visited the facility in August 1985 and viewed work being carried out in 3 principal areas:

(a) Column flotation - based on the 'Flotair' cell commonly used in the phosphate industry. Test work principally carried out on minus 100 mesh coal.

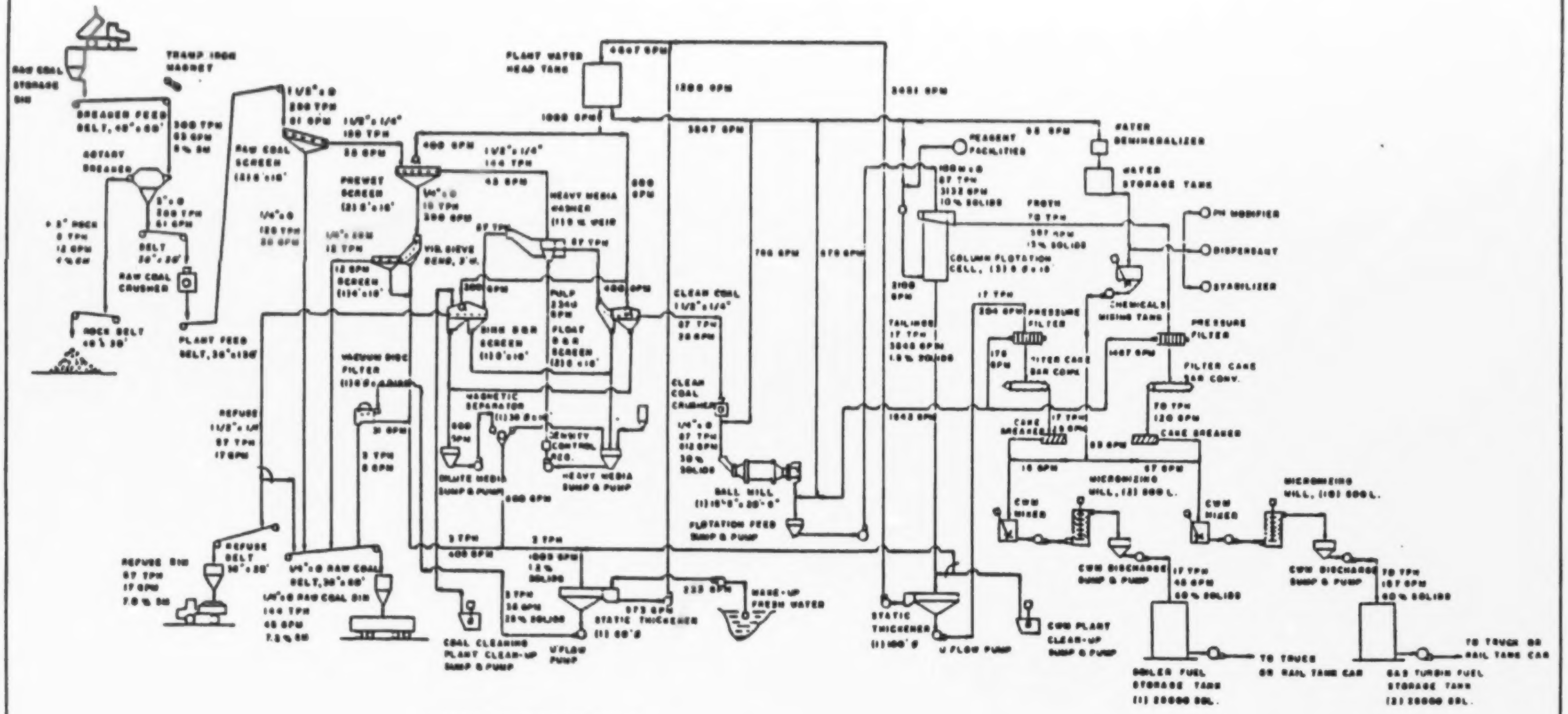
(b) Preparation of coal-water fuel by grinding coal in a ball mill.

(c) High speed centrifuges dewatering fines to a very low level and working as a batch process in series.

The equipment was small scale and test runs were carried out either batch or semi-continuous.

They have also recently carried out a feasibility study on 'The Development, Testing and Manufacture of an Ultra-Clean Coal/Water Mixture'. The objective of the conceptual process design was to develop the production cost of an ultra-clean coal/water mixture based on a specification of less than one percent ash, less than 44 micron top particle size with a minimum 60 percent coal loading. The test coal was cleaned in two stages - heavy medium at 1.30 S.G. and column flotation after grinding the clean coal by ball mill to minus 100 mesh. In order to micronize the coal/water mixture, the flotation product was processed through a stirred ball mill.

A flowsheet of the proposed plant is shown overleaf.


RAW COAL STORAGE BIN
TRAMP IRON MAGNET
BREAKER FEED BELT, 42"x 60'
300 TPH 63 GPM 5% SM
ROTARY BREAKER
+ 3" ROCK 3 TPH 12 GPM 4% SM
3"x 0 300 TPH 61 GPM
BELT 30"x 30'
RAW COAL CRUSHER
ROCK BELT 48"x 30'
PLANT FEED BELT, 30"x 136'
RAW COAL SCREEN (2) 8'x 16'
1 1/2"x 0 300 TPH 61 GPM
1 1/2"x 1/4" 180 TPH 38 GPM
1/4"x 0 120 TPH 30 GPM
PREWET SCREEN (2) 8'x 16'
400 GPM
1 1/2"x 1/4" 144 TPH 42 GPM
1/4"x 0 15 TPH 300 GPM
1/4"x 28M 12 TPH
12 GPM SCREEN (1) 4'x 16'
VIB. SIEVE BEND, 3' W.
87 TPH
HEAVY MEDIA WASHER (1) 10' W. WEIR
PLANT WATER HEAD TANK
4647 GPM
1000 GPM
1200 GPM
3451 GPM
3047 GPM
600 GPM
300 GPM
400 GPM
SINK D&R SCREEN (1) 8'x 16'
PULP 2340 GPM
FLOAT D & R SCREEN (2) 8'x 16'
MAGNETIC SEPARATOR (1) 30"x 8'
600 GPM
DENSITY CONTROL REG.
DILUTE MEDIA SUMP & PUMP
HEAVY MEDIA SUMP & PUMP
600 GPM
VACUUM DISC FILTER
31 GPM
3 TPH 8 GPM
REFUSE 1 1/2"x 1/4" 87 TPH 17 GPM
REFUSE BELT 30"x 30'
REFUSE BIN 87 TPH 17 GPM 7.8% SM
1/4"x 0 RAW COAL BELT, 30"x 80'
1/4"x 0 RAW COAL BIN 144 TPH 45 GPM 7.2% SM
3 TPH
3 TPH
400 GPM
1000 GPM 12% SOLIDS
3 TPH 38 GPM 28% SOLIDS
COAL CLEANING PLANT CLEAR-UP SUMP & PUMP
U'FLOW PUMP
STATIC THICKENER (1) 60' Ø
873 GPM
235 GPM
MAKE-UP FRESH WATER
CLEAN COAL 1 1/2"x 1/4" 87 TPH 28 GPM
CLEAN COAL CRUSHER
1/4"x 0 87 TPH 812 GPM 30% SOLIDS
BALL MILL (1) 15'-0"x 20'-0"
FLOTATION FEED SUMP & PUMP
760 GPM
470 GPM
REAGENT FACILITIES
100M x 0 87 TPH 3132 GPM 10% SOLIDS
2100 GPM
COLUMN FLOTATION CELL, (3) 8 Øx 10
TAILINGS 17 TPH 3048 GPM 1.8% SOLIDS
1042 GPM
FROTH 70 TPH 387 GPM 13% SOLIDS
65 GPM
WATER DEMINERALIZER
WATER STORAGE TANK
PH MODIFIER
DISPERSANT
STABILIZER
CHEMICALS MIXING TANK
17 TPH
204 GPM
PRESSURE FILTER
178 GPM
FILTER CAKE BAR CONV.
PRESSURE FILTER
1467 GPM
FILTER CAKE BAR CONV.
70 TPH 120 GPM
CAKE BREAKER
17 TPH 19 GPM
CAKE BREAKER
83 GPM
16 GPM
67 GPM
MICRONIZING MILL, (2) 800 L.
MICRONIZING MILL, (10) 800 L.
CWM MIXER
CWM MIXER
CWM DISCHARGE SUMP & PUMP
CWM DISCHARGE SUMP & PUMP
17 TPH 46 GPM 60% SOLIDS
70 TPH 187 GPM 60% SOLIDS
STATIC THICKENER (1) 100' Ø
U FLOW PUMP
CWM PLANT CLEAR-UP SUMP & PUMP
BOILER FUEL STORAGE TANK (1) 20000 GAL.
TO TRUCK OR RAIL TANK CAR
GAS TURBIN FUEL STORAGE TANK (3) 20000 GAL.
TO TRUCK OR RAIL TANK CAR

POSSIBLE PRODUCT (BASED ON COAL)

| PRODUCT | TPH | GPM |
|---|---|---|
| 1/4"x 0 COAL | 144 | 44 |
| CWM FOR GAS TURBIN FUEL | 70 | 187 |
| CWM FOR BOILER FUEL | 17 | 46 |
| TOTAL REFUSE | 69 | 15 |
| TOTAL | 300 | 300 |

NOTES: (1) MAKE-UP WATER, 300-65=235 GPM

| | | |
|---|---|---|
| (2) TOTAL REJECTS | 23.0 | % |
| (3) 1/4"x 0 COAL YIELD | 48.0 | |
| (4) TOTAL CWM YIELD | | |
| TURBINE FUEL | 23.3 | |
| BOILER FUEL | 5.7 | |
| | 100.0 | |

FIGURE 1. COAL CLEANING AND COAL WATER MIXTURE PLANT FLOWSHEET OF UNITED COAL COMPANY

## 4.13 OAKRIDGE NATIONAL LABORATORY, TENNESSEE

## OAKRIDGE NATIONAL LABORATORY, TENNESSEE

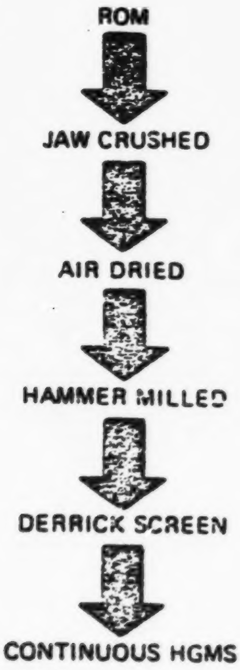
The Oakridge National Laboratory is operated by Union Carbide Corporation for the U.S. Department of Energy. Research into deep cleaning of fine coal has centred around the use of High-Gradient Magnetic Separation (HGMS). Following bench scale research into wet and dry processes, a one-ton per hour Sala-HGMS Mark III carousel continuous separator was used for the pilot plant. It has a maximum capacity of 2 tons per hour. The feed coal was prepared by crushing in a jaw crusher, followed by pulverizing in a hammer mill (Figure 4.13-1). Feed to the HGMS unit was either 24 by 100 mesh or 100 by 325 mesh.

A schematic of the pilot plant flowsheet is shown in Figure 4.13-2. A combination of settling chamber, cyclone, and baghouse was used for the collection of samples from each test run. A specification sheet of the HGMS separator is attached.

The laboratory correlation work was performed on a Sala-HGMS model 10-15-20 (cyclical) unit. This is a batch type device (Figure 4.13-3), and a specification sheet is attached.

## FIGURE 4.13-1

## OAKRIDGE NATIONAL LABORATORY
## CRUSHING SEQUENCE FOR HGMS PILOT PLANT


ROM
JAW CRUSHED
AIR DRIED
HAMMER MILLED
DERRICK SCREEN
CONTINUOUS HGMS

Flowsheet showing preparation procedure of Lower Kittanning and Kentucky No. 9 coal samples.

FIGURE 4.13-2

OAKRIDGE NATIONAL LABORATORY

HGMS ONE-TPH PILOT PLANT

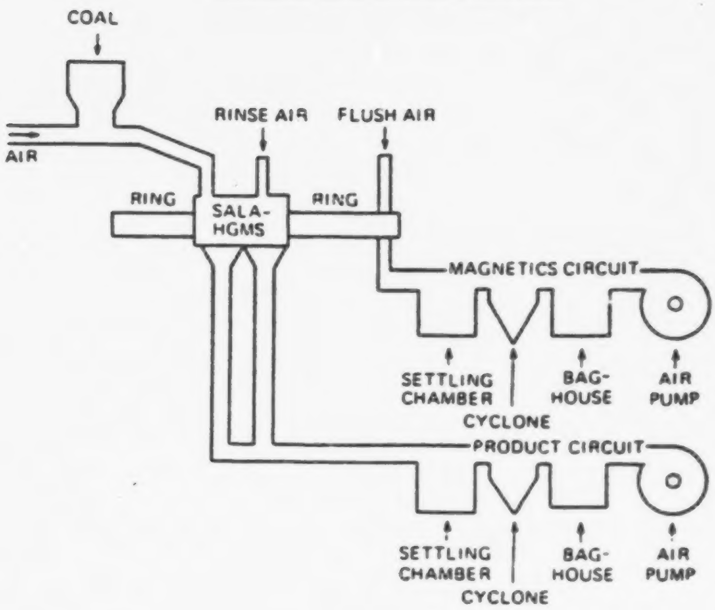
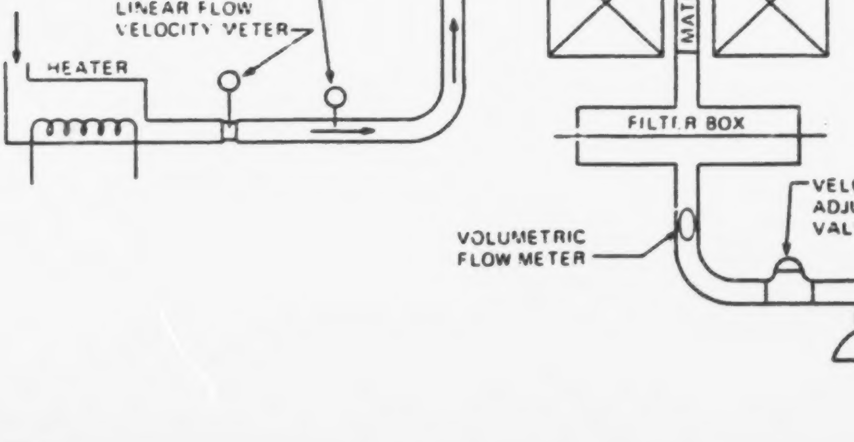

COAL
AIR
RINSE AIR
FLUSH AIR
RING
SALA-HGMS
RING
MAGNETICS CIRCUIT
SETTLING CHAMBER
CYCLONE
BAG-HOUSE
AIR PUMP
PRODUCT CIRCUIT
SETTLING CHAMBER
CYCLONE
BAG-HOUSE
AIR PUMP

FIGURE 4.13-3

OAKRIDGE NATIONAL LABORATORY

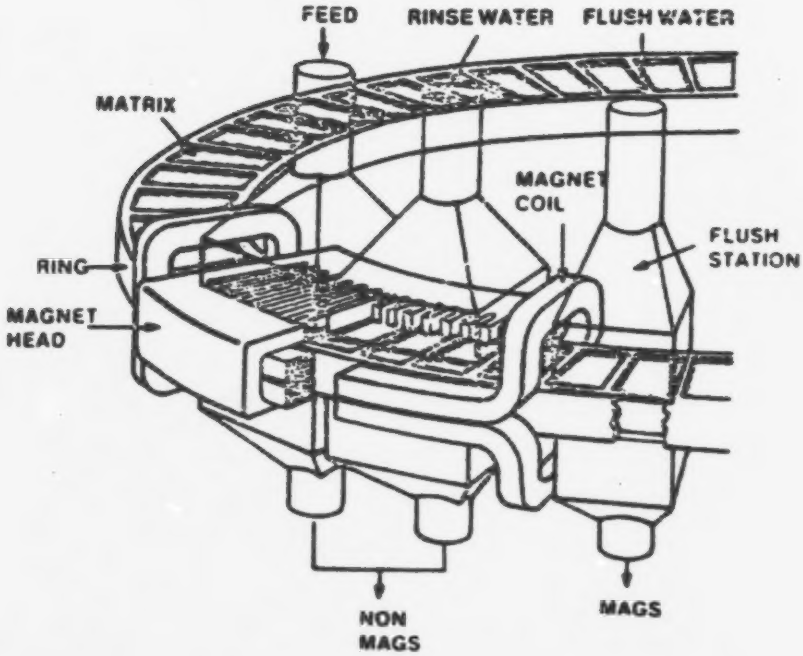
HGMS LABORATORY SCALE UNIT


VIBRATORY FEEDER
MAGNET
MATRIX
THERMOMETER
LINEAR FLOW VELOCITY METER
HEATER
FILTER BOX
VELOCITY ADJUSTING VALVE
VOLUMETRIC FLOW METER
AIR PUMP

## Appendix B

## SPECIFICATIONS OF THE CAROUSEL UNIT

(Source: Sala Magnetics, Inc., 1979, SMI Bulletin No. S79-0001)



SALA-HGMS* Continuous High Gradient Magnetic Separators use a filamentary matrix of ferromagnetic material such as ferritic stainless steel screens or wool. When placed in the strong and uniform background magnetic fields produced in SMI designed magnets, very strong magnetic forces are developed on the filament edges.

The **matrix** is mounted in a rotating, annular **ring** which carries it through the **magnet head** where the magnetic field is generated and the separation of the slurry feed takes place. Magnetically trapped particles in the **matrix** are washed off when the **ring** enters the **flush station**.

The **magnet head** design allows the use of filamentary matrices which can retain very fine and/or weakly paramagnetic materials. The filamentary **matrix** is designed to match the particle size range of the slurry. The **matrix** design also allows processing of strongly magnetic materials without clogging. The matrix-bearing **ring** is supported by guide **rollers** and driven by one or more electric motors. The **rollers, motor(s),** and one or more **magnet head(s)** are mounted on a rigid support frame.

**Seals** mounted on the **ring** allow independent control of feed and flush velocity to enhance the separation and to increase the flushing efficiency of the magnetics. This control also significantly reduces the wear of the matrix material even with highly abrasive slurries.

Fig. B.1. Features of SALA-HGMS MARK III Carousel-type continuous HGMS.

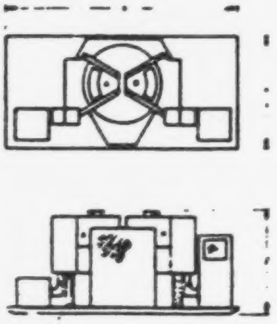
**SALA-HGMS®** Continuous High Gradient Magnetic Separators include magnet(s) assembly(ies) (magnet coil, magnet return frame), ring, matrix, and support structure; process piping and valving, power supply unit(s); process controller and instrumentation. A closed loop cooling system may be provided for the magnet and power supply if suitable cooling water (approximately drinking water quality; 0.15 gpm per kilowatt of rated power) is not available. The system is provided with fail safe protection through thermal switches and a flow switch in the main cooling system; fail safe alarm triggering circuitry, operational in the event of component failure; and external interlocks to protect the system in the event of equipment failure. Power supplies (rectifiers) are built in accordance with the customer's requirements (voltage, frequency). An appropriate feed system and means for products collection and handling should be provided by the customer or are available through SMI.

CAROUSEL MODEL
120 A B

| | x | y | z |
|---|---|---|---|
| Overall Dimensions (m) | 4 | 2 | 2 |

| | |
|---|---|
| Basic Weight (tons) | 4.5 |
| Capacity/head, max (t/h) | 3 |
| Ring Drive Power (kw) | 2.2 |

| Field Rating | Add'l Wt/head (t) | Power/head (kw) |
|---|---|---|
| 5 kG | 1.5 | 25 |
| 10 kG | 2.3 | 75 |
| 15 kG | 3.5 | 160 |
| 20 kG | 5.5 | 250 |



CAROUSEL MODEL
185 A B

| | x | y | z |
|---|---|---|---|
| Overall Dimensions (m) | 5 | 3 | 2.5 |

| | |
|---|---|
| Basic Weight (tons) | 6 |
| Capacity/head, max (t/h) | 25 |
| Ring Drive Power (kw) | 6 |

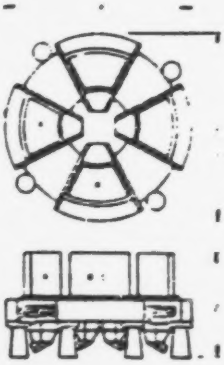
| Field Rating | Add'l Wt/head (t) | Power/head (kw) |
|---|---|---|
| 5 kG | 4.5 | 25 |
| 10 kG | 10 | 75 |
| 15 kG | 16 | 170 |
| 20 kG | 35 | 250 |

CAROUSEL MODEL
350 A B C D

| | x | y | z |
|---|---|---|---|
| Overall Dimensions (m) | 6 | 6 | 4 |

| | |
|---|---|
| Basic Weight (tons) | 12 |
| Capacity/head max (t/h) | 100 |
| Ring Drive Power (kw) | 8.5 |

| Field Rating | Add'l Wt/head (t) | Power/head (kw) |
|---|---|---|
| 5 kG | 18 | 40 |
| 10 kG | 45 | 125 |
| 15 kG | 95 | 175 |
| 20 kG | 200 | 250 |



CAROUSEL MODEL
480 A B C D

| | x | y | z |
|---|---|---|---|
| Overall Dimensions (m) | 8 | 5 | 4.5 |

| | |
|---|---|
| Basic Weight (tons) | 18 |
| Capacity/head max (t/h) | 250 |
| Ring Drive Power (kw) | 12 |

| Field Rating | Add'l Wt/head (t) | Power/head (kw) |
|---|---|---|
| 5 kG | 36 | 100 |
| 10 kG | 95 | 175 |
| 15 kG | 190 | 250 |
| 20 kG | 300 | 300 |

**NOTES:**

1 — Custom designs for reduced power consumption and/or different field intensities are available.

2 — Models 120 and 185 are available with one or two heads; Models 350 and 480 are available with one to four heads. Machine heads in the same unit can work in parallel or in series and can be built for the same or different magnetic field intensities.

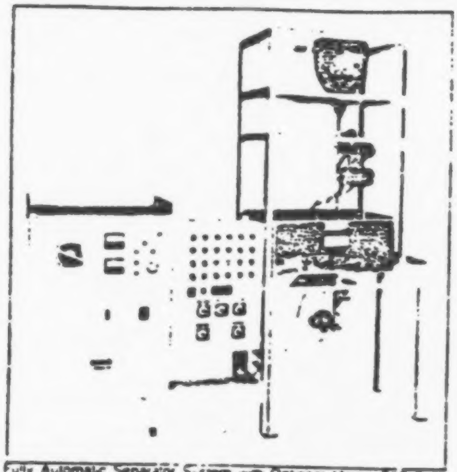
3 — SMI reserves the right to change the specifications.

Fig. B.2. Specifications of SALA-HGMS MARK III Carousel-type continuous HGMS.

## Appendix C

## SPECIFICATIONS OF THE CYCLIC UNIT

## SALA-HGMS® 10 cm Bore Cyclic Magnetic Separator



Fully Automatic Separator System with Optional Model GFT S-1 Gravity Feed System

### High Gradient Magnetic Separation

SALA-HGMS® cyclic magnetic separators are designed to separate or filter very fine magnetic and weakly magnetic particles from fluid streams at high process rates. Particles are trapped in the magnetized filamentary matrix by the strong magnetic forces produced along the edges of the fine ferromagnetic filaments.

The SALA-HGMS® 10 cm (4 inch) Bore Cyclic Magnetic Separator may be used for laboratory or on-site test programs, for pilot scale operations and for small volume industrial applications. Results obtained with the 10 cm bore separator are used to design larger capacity systems.

Numerous applications for SALA-HGMS® cyclic magnetic separators exist in mineral processing, water treatment and chemical feed purification.

### Applications

☐ Purification of clays and other industrial minerals including talc, magnesite, calcite, chalk, dolomite, feldspar, bauxite.

☐ Purification of glass sands including ilmenite, rutile.

☐ Beneficiation of weakly magnetic minerals including hematite, goethite and siderite

☐ Beneficiation of other weakly magnetic ores including minerals containing nickel manganese, chromium, molybdenum uranium and tungsten

☐ Treatment of steel mill process and waste waters

☐ Treatment of steam condensates for fossil or nuclear-fuel fired power generators

☐ Purification of catalyst-contaminated chemical feeds and waste waters

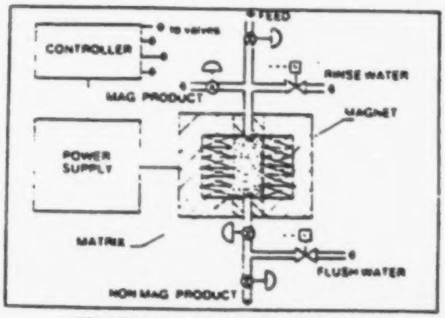
☐ Recovery/recycling of lubricants and continuous removal of wear particles

In the cyclic operation of a SALA-HGMS® magnetic separator, magnetic particles trapped on the matrix during the feed cycle (magnet on) are easily washed off the matrix and recovered during the flush cycle (magnet off). A simple system of valves is used in order to collect the magnetic and nonmagnetic products separately.

### Fully Automatic High Gradient Magnetic Separation

Feed and flush cycles in the SALA®-HGMS® 10 cm Bore Separator may be regulated by an automatic controller Model ACS-7 which, in the automatic mode, sequences and times the opening and closing of solenoid operated valves. The ACS-7 can also be used to regulate pumps, mixers, and other components of the feed system. In the manual mode, switches on the ACS-7 permit remote operation of the valves and other components.

Magnetic field strength, flow velocity and matrix loading can be varied independently over a wide range to achieve the desired separation. Additionally, extensive flow-sheet refinement is possible through simple reprogramming of the automatic control system.



*TOP FEED, BACK FLUSH ARRANGEMENT*
Many other arrangements possible

Fig. C.1. Specifications of SALA-HGMS Model 10-15-20.

## 4.14 CONSOL PILOT PLANT, LIBRARY, PENNSYLVANIA

Kilborn Engineering (B.C.) Ltd. / 1380 Burrard St., Vancouver, Canada V6Z 2B7
Telex: 04-507734, Tel: (604) 669-8811

November 22, 1985

Conoco Inc.
Coal Research Division
4000 Brownsville Road
Library, PA 15129
U.S.A.

Attention: Mr. James Clancey
Director - Engineering

Dear Mr. Clancey:

Kilborn has recently been awarded a contract for the development and design of a pilot plant for the 'deep cleaning' of coal. The plant will be part of the Canadian Energy, Mines and Resources' Coal Research Facility at Edmonton, Alberta. The initial phase of the project is a review of existing plant facilities and relevant cleaning processes.

I am writing to ask if you could assist in supplying any details of your facility and some of the research projects you are involved in. I realize, of course, that as a private company much of your work will not be for public release, but would request any non-proprietary information that you might have available.

The 'deep cleaning' section will be an extension to the existing pilot plant (Batac jig, heavy medium cyclone, water-only cyclone, froth flotation, etc.), and will likely consist of a fine grinding section, followed by process options such as froth flotation, oil agglomeration, high density magnetic separation and electrostatic separation.

If you are able to provide any assistance in this area, we would be most grateful indeed.

Yours very truly,

KILBORN ENGINEERING (B. C.) LTD.

[redacted], P.Eng.
Manager, Coal Preparation

ADW/mr

## 4.15 UNIVERSITY OF WESTERN ONTARIO

## UNIVERSITY OF WESTERN ONTARIO

The University of Western Ontario has specialized in the deep cleaning of fine coal by electrostatic methods. The research facilities are relatively small scale and batch operated. A typical experimental run would use 100 grams of pulverized coal fed in at 10 grams per time.

The equipment used in the laboratory is of two types, namely:

(a) Triboelectrification using a separation tower (Figure 4.15-1).

(b) Triboelectrification using a dilute phase electrostatic loop (Figure 4.15-2).

Details os both these pieces of equipment have been given in Section 3.7.3.

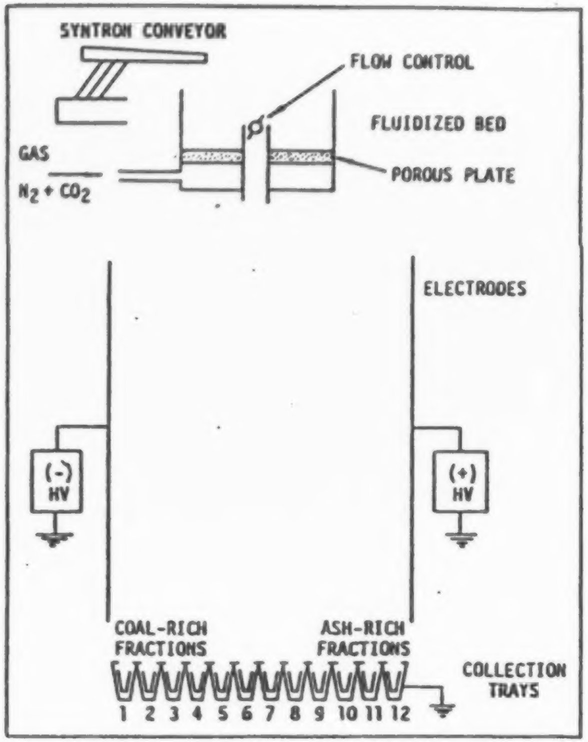

SYNTRON CONVEYOR
FLOW CONTROL
FLUIDIZED BED
GAS
$N_2 + CO_2$
POROUS PLATE
ELECTRODES
(-) HV
(+) HV
COAL-RICH FRACTIONS
ASH-RICH FRACTIONS
COLLECTION TRAYS
1 2 3 4 5 6 7 8 9 10 11 12

FIGURE 1. Separation tower.

FIGURE 4.15-1: UNIVERSITY OF WESTERN ONTARIO - ELECTROSTATIC SEPARATION TOWER

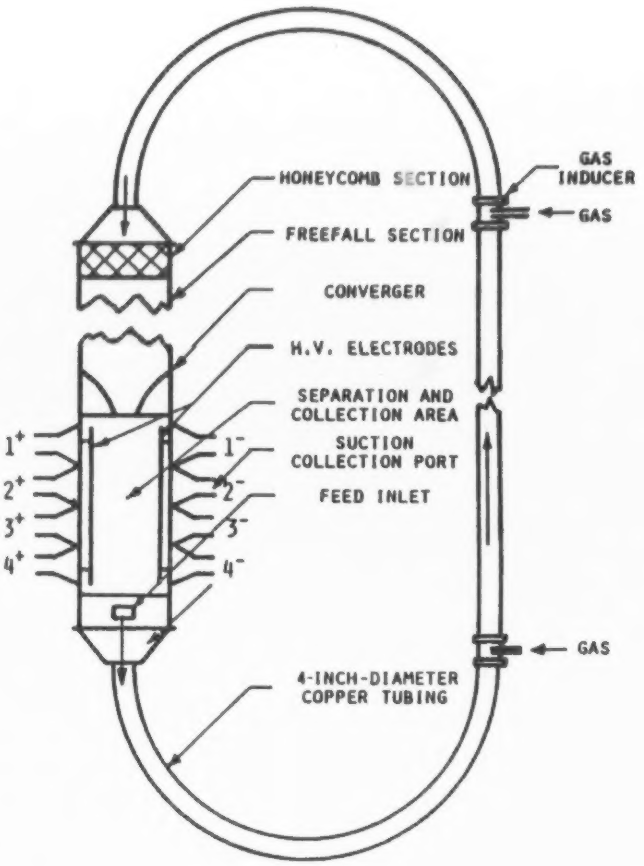

HONEYCOMB SECTION
FREEFALL SECTION
CONVERGER
H.V. ELECTRODES
SEPARATION AND COLLECTION AREA
SUCTION COLLECTION PORT
FEED INLET
4-INCH-DIAMETER COPPER TUBING
GAS INDUCER
GAS
GAS
1+
2+
3+
4+
1-
2-
3-
4-

FIGURE 4.15-2: UNIVERSITY OF WESTERN ONTARIO - ELECTROSTATIC LOOP

## 4.16 AMAX RESEARCH AND DEVELOPMENT, INC.
## GOLDEN, COLORADO

## AMAX RESEARCH AND DEVELOPMENT, INC.
## GOLDEN, COLORADO

AMAX operates a small scale pilot plant and laboratory facilities at Golden. They have facilities for the crushing and pulverizing of coal (using a stirred ball mill) and small scale froth flotation and heavy medium (organic liquids) equipment.

Fine clean coal is used as feedstock to a continuous chemical cleaning (leaching) pilot plant using a two-stage caustic and acid leach process. Sufficient 'deep' cleaned low ash coal has been prepared to carry out burning tests on a coal-water fuel.

# 5.0 COAL MILLING TECHNICAL SURVEY

# 5.0 COAL MILLING TECHNICAL SURVEY

## 5.1 GENERAL

The conventional methods of milling coal for the production of pulverized fuel for power stations are as follows:

- Air swept tumbling ball mills
- Air swept roller race mills
- Hammer or impact mills.

In the production of coal-water fuel, milling is generally carried out by wet ball milling. There are, however, a few instances where dry milling processes are used.

In pilot plants where coal is milled prior to 'deep cleaning' processes, the wet ball mill is almost exclusively used. Available details of these plants have been given in Section 4.0.

This survey reviews the milling flowsheets used in some of the coal-water fuel plants in various parts of the world. In recent years, there have been many such plants built. This review does not claim to cover the majority of these plants, but reports on some of those where information is available in the technical press.

## 5.2 NYCOL PROCESS

Nycol AB is a Swedish company which was formed in 1981. A cooperation has been developed with the Advanced Fuels Technology Group (A Division of Sohio Alternate Energy Development Company). The coal-based fuels are preferably cleaned and delivered in either liquid or powder form. As seen from the process flowsheet (Figure 5.2-1), wet or dry ball milling may be used.

The production of the Nycol fuels started at Stora Vika, 60 kilometres south of Stockholm. In June 1985, additional capacity was added and the plant now has the capacity to produce 80,000 tonnes per year of clean coal and 40,000 tonnes per year of raw coal. In 1984, production of pulverized coal was started at Skovde in south central Sweden.

## 5.3 CARBOGEL PLANTS

### 5.3.1 Cape Breton Development Corporation (CBDC)

The CBDC - Carbogel Plant was designed for 4 tonnes per hour production. The flowsheet is shown in Figure 5.3-1. Primary and secondary wet ball milling is carried out. Size classification to control particle top size is carried out with Derrick classification screens.

### 5.3.2 Carbogel Japan, Inc.

In 1984, Carbogel and JGC built a coal-water slurry plant in Japan. The design capacity of the plant is 4.5 tonnes per hour of CWM containing 70 percent weight of coal. The flowsheet (Figure 5.3-2) is similar to the CBDC flowsheet, consisting of primary and secondary wet ball mills followed by froth flotation.

The plant consists of the following equipment:

- Crusher, primary and secondary wet mills;
- Screen with 200 microns aperture;
- 6 rougher froth cells;

FIGURE 5.2-1

NYCOL (SWEDEN) COAL-WATER MIXTURE
PROCESS PLANT

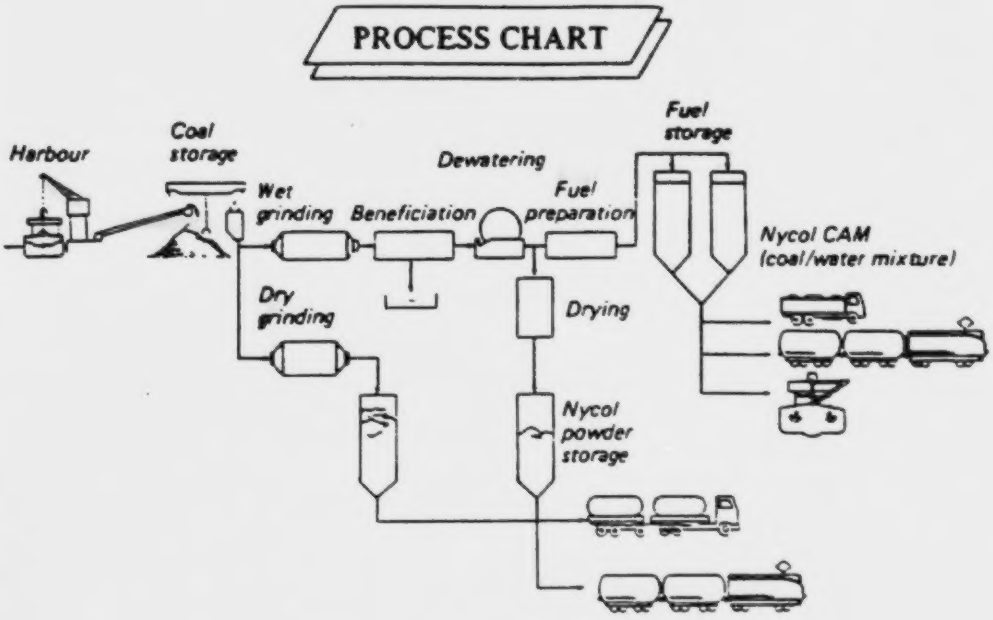
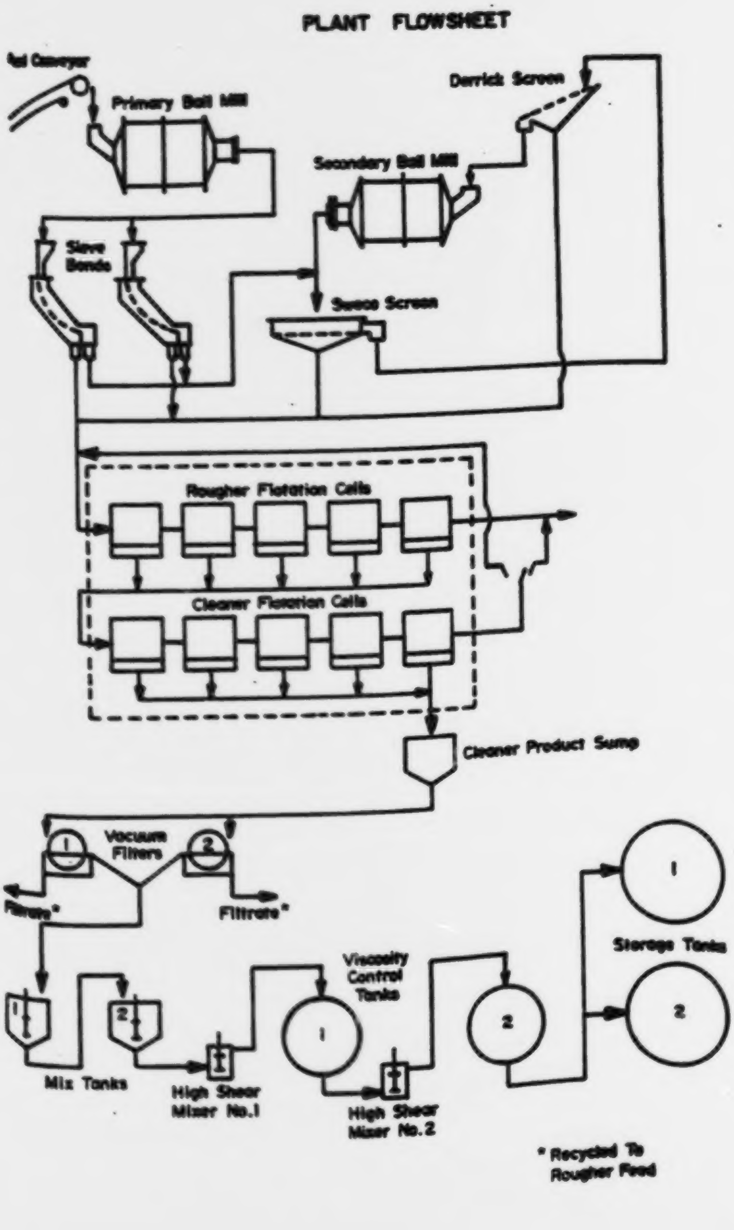

PROCESS CHART
Harbour
Coal storage
Wet grinding
Beneficiation
Dewatering
Fuel preparation
Fuel storage
Nycol CAM (coal/water mixture)
Dry grinding
Drying
Nycol powder storage

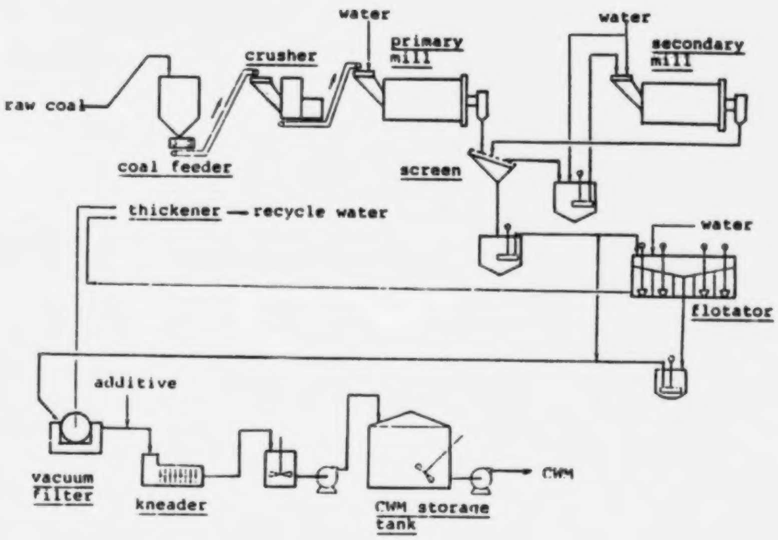
FIGURE 5.3-1

CAPE BRETON DEVELOPMENT CORPORATION'S CARBOGEL COAL-WATER FUEL PROJECT


PLANT FLOWSHEET
ed Conveyor
Primary Ball Mill
Derrick Screen
Secondary Ball Mill
Sieve Bends
Sweco Screen
Rougher Flotation Cells
Cleaner Flotation Cells
Cleaner Product Sump
Vacuum Filters
1
2
Filtrate*
Filtrate*
Viscosity Control Tanks
Storage Tanks
1
2
1
2
1
2
Mix Tanks
High Shear Mixer No.1
High Shear Mixer No.2
* Recycled To Rougher Feed

## FIGURE 5.3-2

## CARBOGEL JAPAN, INC. - COAL-WATER MIX PROCESS PLANT


water
primary mill
water
secondary mill
crusher
raw coal
coal feeder
screen
thickener — recycle water
water
flotator
additive
vacuum filter
kneader
CWM storage tank
CWM

- 4 cleaner froth cells;
- Vacuum filter;
- Kneader (to mix additives with filter cake);
- CWM storage tanks;
- Process water recirculation system.

## 5.4 ATLANTIC RESEARCH CORPORATION - ARC-COAL

The plant is in the design stage, and the proposed flowsheet is shown in Figure 5.4-1. The grinding system consists primarily of a cage mill and ball mill in series. The general approach to achieving a high availability is therefore to provide sufficient equipment and surge capacity so that the grinding system will not be shut down by failures in the upstream or downstream portions of the plant. Cage mills are expected to have a higher failure rate and a more frequent maintenance rate than ball mills. In this arrangement, any failure of the cage mill requires the ball mill to operate in a recirculation mode. No size classification equipment is shown however.

## 5.5 STATE SCIENCE AND TECHNOLOGY COMMISSION (SSTC) - PEOPLE'S REPUBLIC OF CHINA

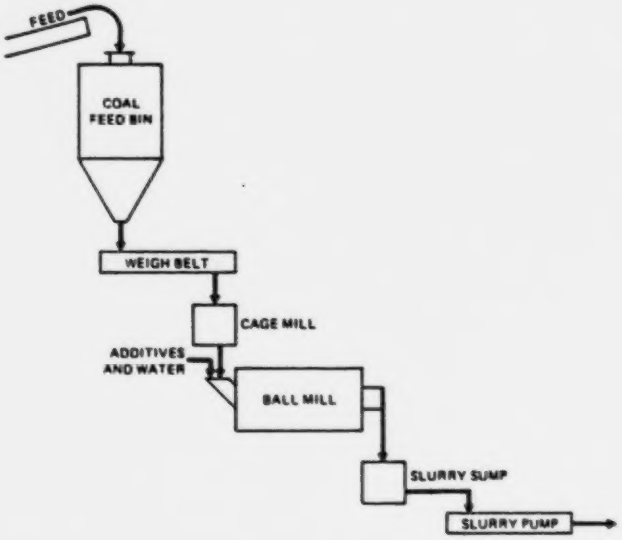
A coal-water fuel production circuit has been installed in an existing coal preparation plant (Figure 5.5-1). A portion of the dewatered clean coal is fed to the CWF plant in an adjacent building. A second-hand ball mill (1.5 metre diamter by 5.7 metre length) is used for grinding, and size classification of the product is carried out by a gyratory screen. The main features of the process include:

(a) A calibrated quantity of water and surfactant is added to the minus 6 millimetre ball mill feed.

(b) Ground coal with the desired particle size distribution and with a solids concentration of 69 percent by weight is

## FIGURE 5.4-1

## ATLANTIC RESEARCH CORPORATION
## ARC COAL PROCESS

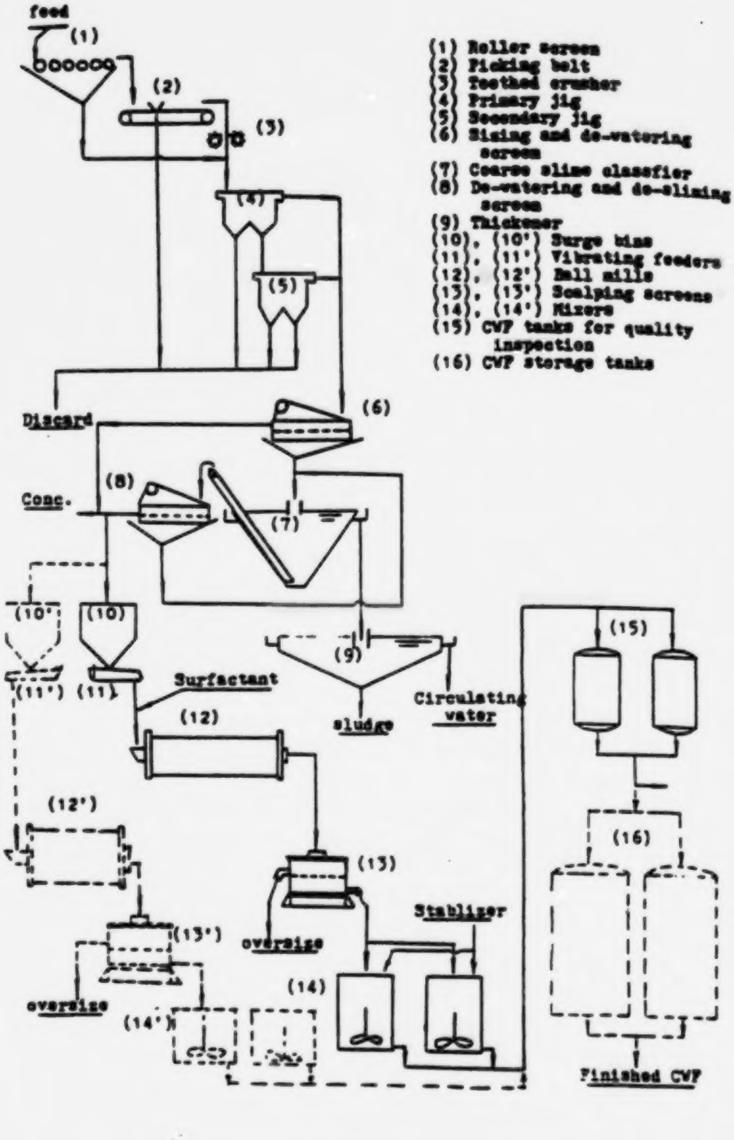

FEED
COAL FEED BIN
WEIGH BELT
CAGE MILL
ADDITIVES AND WATER
BALL MILL
SLURRY SUMP
SLURRY PUMP

TYPICAL GRINDING SETUP FOR COLD WATER MIXTURES

## FIGURE 5.5-1

## STATE SCIENCE AND TECHNOLOGY COMMISSION
## (PEOPLE'S REPUBLIC OF CHINA)

## COAL-WATER FUEL ADDITION TO WASHERY


feed
(1)
(2)
(3)
(4)
(5)
(6)
Discard
(8)
Conc.
(7)
(10')
(10)
(9)
(15)
(11')
(11)
Surfactant
(12)
sludge
Circulating water
(12')
(16)
(13)
(13')
Stabliser
oversize
oversize
(14)
(14')
Finished CWF
(1) Roller screen
(2) Picking belt
(3) Toothed crusher
(4) Primary jig
(5) Secondary jig
(6) Sizing and de-watering screen
(7) Coarse slime classfier
(8) De-watering and de-sliming screen
(9) Thickener
(10), (10') Surge bins
(11), (11') Vibrating feeders
(12), (12') Ball mills
(13), (13') Scalping screens
(14), (14') Mixers
(15) CWF tanks for quality inspection
(16) CWF storage tanks

discharged.

(c) Stabilizer is added to the classifying screen underflow and the mixture conditioned to a finished CWF product.

Test runs of this CWF preparation circuit were carried out by varying the capacity from 1.4 to 4.5 tonnes per hour finished product. It was found that a capacity of 3.5 tonnes per hour gave the best performance.

A second CWF plant in the People's Republic of China uses a 'fine grinding mill' which appears to be a roller-race type mill.

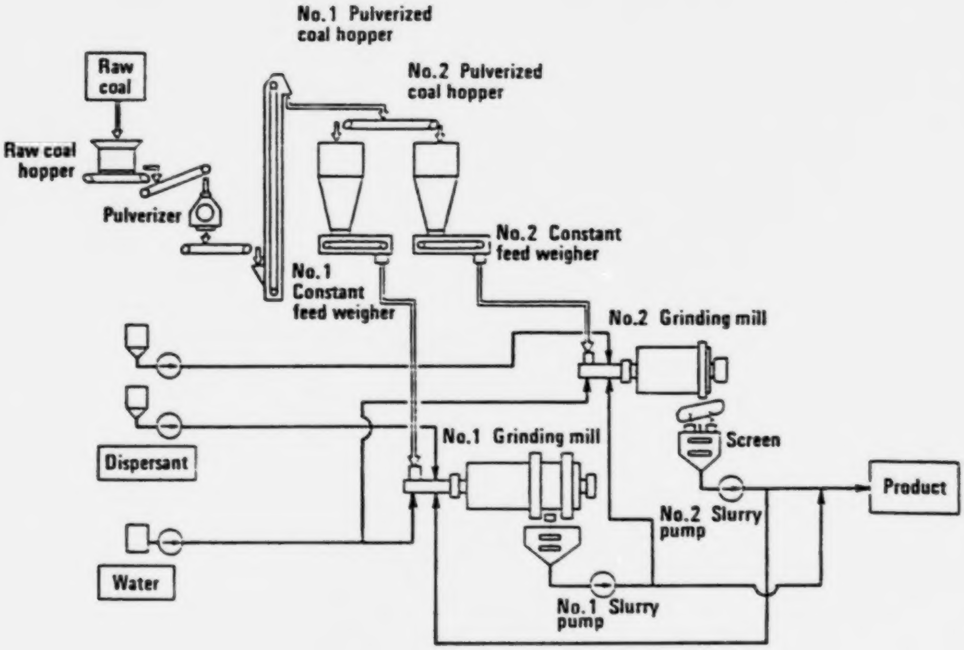
## 5.6 ELECTRIC POWER DEVELOPMENT COMPANY (EPDC) - JAPAN

The research and development of Highly-Loaded Coal-Water Slurry (HCWS) is in the pilot plant stage at the EPDC's Wakamatsu Coal Utilization Technology Research Centre. The flowsheet is shown in Figure 5.6-1, and the equipment specification is shown in Figure 5.6-2. The equipment's features are as follows:

(a) Two wet type ball mills are installed. They allow two-stage grinding continuous operation.
(b) The revolution speed of either of these two mills can be varied.
(c) The grinding power consumption can easily be measured with a torque meter.
(d) The HCWS coal concentration can be easily controlled by proportion control of the coal, water and slurry supplied.

The raw coal is crushed to minus 3 millimetres and fed to the mill at 0.6 - 2 tonnes per hour. Water and dispersant are fed to the mill from the respective storage tanks. If two-stage milling is required, the first-stage milled coal at 55-60

## FIGURE 5.6-1
## ELECTRIC POWER DEVELOPMENT COMPANY (JAPAN)
## HIGHLY-LOADED COAL-WATER SLURRY PREPARATION PLANT



No.1 Pulverized coal hopper
No.2 Pulverized coal hopper
Raw coal
Raw coal hopper
Pulverizer
No.2 Constant feed weigher
No.1 Constant feed weigher
No.2 Grinding mill
No.1 Grinding mill
Screen
Dispersant
Product
No.2 Slurry pump
Water
No.1 Slurry pump

## FIGURE 5.6-2
## ELECTRIC POWER DEVELOPMENT COMPANY (JAPAN)
## EQUIPMENT SPECIFICATION

| Term | Particular | Number | Term | Particular | Number |
|---|---|---|---|---|---|
| Pulverizer | 3,500 kg/H, 15 KW | 1 | No.1 Collecting Tank | 4 m$^3$<br>2,000 mm$^{\phi}$ x 1,900 mm$^{H}$<br>Agitator 1.5 KW | 1 |
| No.1 Constant Feed Weigher | Max. 1,500 kg/H<br>600 mm$^{W}$ x 3,000 mm$^{L}$ | 1 | No.2 Collecting Tank | 2.5 m$^3$<br>1,700 mm$^{\phi}$ x 1,900 mm$^{H}$<br>Agitator 1.5 KW | 1 |
| No.2 Constant Feed Weigher | Max. 1,500 kg/H<br>600 mm$^{W}$ x 5,000 mm$^{L}$ | 1 | No.1 Slurry Pump | Screw type<br>2 m$^3$/H, 15 kg/cm$^2$<br>3.7 KW (V·S motor) | 1 |
| No.1 Grinding Mill | Wet type ball mill<br>(Peripheral discharge type)<br>1,200mm$^{\phi}$x2,400/4,000mm$^{L}$<br>55 KW | 1 | | | |
| No.2 Grinding Mill | Wet type ball mill<br>(Peripheral discharge type)<br>1,200 mm$^{\phi}$ x 2,400 mm$^{L}$<br>45 KW (V·S motor) | 1 | No.2 Slurry Pump | Screw type<br>2 m$^3$/H, 15 kg/cm$^2$<br>3.7 KW (V·S motor) | 1 |

percent solids is fed to the secondary mill with fresh minus 3 millimetre coal, to achieve the desired coal concentration. Further dispersant is added and the mixture fed to the second stage. Although the product is shown passing over a screen, it is not clear if this is a size classification circuit. The final product varies between 72-80 percent solids by weight, depending on which dispersant is used.

## 5.7 FLUIDCARBON PROCESS - SWEDEN

The fuel production plant is at Malmoe and has a capacity of 25 tonnes per hour (dry product). No flowsheet was available, but the process description is as follows:

Grinding is carried out in rubber-lined wet ball mills. A diaphragm just inside the discharge is employed to regulate the slurry level and thus controls the retention time in the mill. For most bituminous coals, the power consumption to reach 80 percent minus 200 microns in the mill varies from 15-30 kilowatt hours per metric tonne feed. The ball mills have replaceable rubber liners which have a baffling action because of a wave shape which keys the ball charge to the shell and prevents slippage.

Hydrocyclones and sieve bends are used to classify the product. The fine coal product is then subjected to froth flotation using reagents that are compatible with the dispersants added later in the process. Following the flotation step, the resulting clean coal suspension is dewatered to 20-25 percent moisture in rotary drum vacuum filters, using filter aids.

The final step of the process is the mixing system where dispersants and balance water are carefully mixed to form a homogenous fluid. A proprietary surfactant/cosurfactant system, with a well defined charge density, is used as a dispersant to give appropriate rheology and stability of the Fluid Carbon fuel.

A smaller pilot plant production unit (3 tonnes per hour) has been erected for further optimization of the process, and evaluation of different coal and additives.

## 5.8 ANACONDA COAL-WATER SLURRY FUEL

Anaconda has constructed a small (capacity unspecified) test plant for the production of coal-water fuel. A schematic flowsheet is shown in Figure 5.8-1.

Clean coal from the heavy medium circuit of a preparation plant and coal prepared with heavy liquids were both used as feed stock.

Size reduction of the coal was achieved by grinding in a conventional wet tumbling mill and a stirred ball mill. Coal grinding down to medium sizes around 75 microns was carried out in a tumbling ball mill, while the ultrafine coal fraction was produced with a stirred ball mill. Ultrafine grinding showed increased grinding efficiency as the viscosity of the slurry in the mill decreased. This was reflected by an increase in efficiency as the percent solids decreased and the dispersant concentration increased.

The equipment used was as follows:

Straub Ball Mill
- 2 feet diameter by 5 feet length
- 10 horsepower motor
- 600-pound ball charge (1 inch top size)
- 19 rpm.

## FIGURE 5.8-1

## ANACONDA - COAL-WATER SLURRY PROCESS

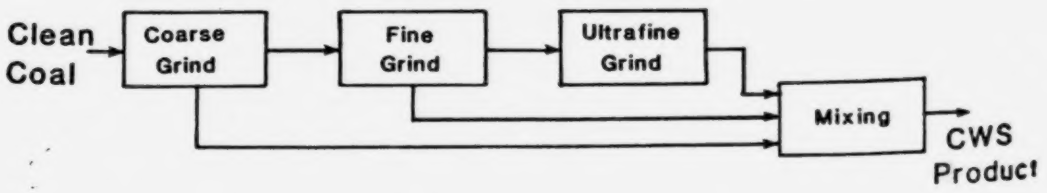

Clean Coal
Coarse Grind
Fine Grind
Ultrafine Grind
Mixing
CWS Product

Figure 1. Schematic representation of Coal-Water Slurry Preparation Process.

Stirred Ball Mill - Vertical mill (20 gallon capacity)
- 700-pound ball charge (¼ inch top size)
- 40 horsepower motor
- 228 rpm impeller.

Mixer - Double screw 10 gallon pug mill

Classifying Screens - Sweco vibrating screens and DSM sieve bends (325 mesh).

Magnetic Separator (To remove entrained magnetite) - 18 inches by 30 inches L-3 Eries.

Vacuum Filters - Dorr-Oliver 3 feet by 4 feet drum filter.

## 5.9 SALZGITTER DENSECOAL - WEST GERMANY

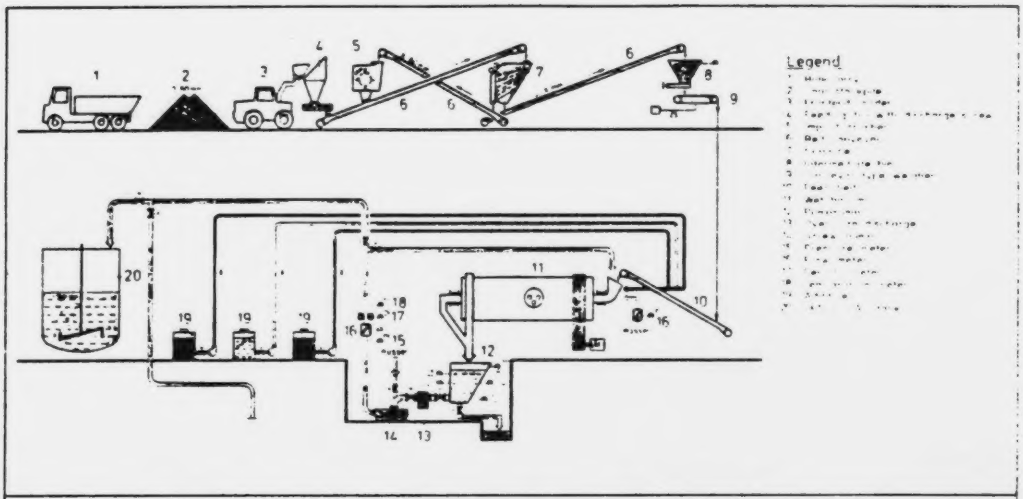
The 5 tonne per hour pilot plant (Figure 5.9-1) in West Germany consists of coal crushing, dosing unit, ball milling and slurry preparation.

A front-end loader is used to fill run-of-mine coal into the feed bin, from where it is fed to a Mogensen sizer and oversize crushed by impact crusher. The crushed coal is fed from the intermediate bin over a dosing weight-belt into the wet ball mill. The mill is 1.4 metres diameter and 4.6 metres length. Water and additives are also charged to the mill.

After being discharged from the mill, the dense coal flows into a slurry inspection tank, which is fitted with an in-process viscometer, temperature probe, pH meter and on-line particle size analyzing system. No size classification system exists, but it is possible to pump the product back to the mill if size limit values are exceeded.

## FIGURE 5.9-1

## SALZGITTER DENSECOAL PROCESS PLANT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Legend

Wet milling of DENSECOAL

## 5.10 OTHER COAL-WATER PLANTS

"COALIQUID" plants are situated in Kentucky, Florida, Israel and Korea. The first 3 plants are reported to use wet milling in cage and 'pin' mills, and the Korean plant is a dry roller mill.

The "COMOCO" Plant is reported to use a two-stage pulverizing process to produce 95 percent less than 325 mesh size coal. It is not reported if the pulverizing is wet or dry.

KILBORN

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November 22, 1985

Mr. Robert J. Linn
Kennedy Van Saun Corporation
Danville, Pennsylvania 17821
U.S.A.

Dear Bob:

Following our recent telephone conversation, I would like to formalize my request for available data on a 3 to 5-ton per hour wet ball milling circuit. Kilborn is just starting the development and design of a pilot plant on behalf of the Canadian Government's (CANMET) Coal Research Facility at Edmonton, for the 'deep cleaning' of fine coal. The coal will be wet ball milled and subsequently cleaned to a low ash by a variety of test processes (oil agglomeration, froth flotation, high intensity magnetic separation, etc.).

Any relevant non-proprietary information you have on small ball mills and their installation in existing pilot plants would be greatly appreciated.

Yours very truly,

KILBORN ENGINEERING (B. C.) LTD.

Tony Walters.

**A. D. Walters**, P.Eng.
Manager, Coal Preparation

ADW/mr

# 6.0 CONCLUSION AND RECOMMENDATIONS

# 6.0 CONCLUSION AND RECOMMENDATIONS

Following the review of processes developed or being developed for the deep cleaning of fine coal, and a survey of test pilot plants, Kilborn's conclusions on the suitability of each process for installation in the pilot plant now follows. The decisions have been based on: (a) the demonstrated ability of the process to continuously produce low ash product, and (b) a process that is likely to have commercial application, and considered worthwhile to carry out research on the suitability of processing Canadian coals.

## 6.1 FROTH FLOTATION

Kilborn recommends the installation of two-stage flotation cells as a worthwhile research area. The section should contain a well-designed reagent storage, dispersion (both air and water) and delivery system.

## 6.2 GRAVITY SEPARATION

Kilborn recommends that no new gravity separation equipment be installed, but that facilities be installed to permit future rerouting of the pulverized coal to the gravity separation processes in the main pilot plant.

## 6.3 OIL AGGLOMERATION

Kilborn recommends the installation of an oil agglomeration and pelletizing pilot section. Kilborn feels that with the introduction of small scale commercial plants already under way, much useful pilot scale research needs to be done on Canadian coals.

## 6.4 HIGH GRADIENT MAGNETIC SEPARATION

Kilborn recommends the installation of a continuous carousel-type magnetic separation unit, with consideration given to facilities to pre-treat the pulverized feed coal by physical and chemical methods to enhance magnetic susceptibility.

## 6.5 SELECTIVE FLOCCULATION

Kilborn does not recommend the installation of this process on the grounds that it is not well-enough advanced, and the space requirements might be too great. However, it may be contemplated as a possible form of pre-treatment prior to either froth flotation or oil agglomeration, and this should be taken into account in the design.

## 6.6 CHEMICAL COMMINUTION AND CLEANING

Kilborn does not recommend this process because the many processes available have not been successfully demonstrated at pilot plant scale, and continuous processes have high capital and operating costs and are, therefore, usually difficult to justify.

## 6.7 ELECTROSTATIC SEPARATION

Kilborn recommends the installation of an off-line pilot installation. Kilborn feels it is a process with good commercial potential in special applications, although the electrostatic separation equipment pertaining to coal is still only just reaching the pilot plant stage of development.

## 6.8 TRUE HEAVY LIQUIDS SEPARATION

Kilborn does not recommend the installation of this process. Although considerable development has been carried out on the Otisca process, it is proprietary, relatively sophisticated and high in capital costs.

## 6.9 AIR SEPARATION

Kilborn does not recommend the installation of this process on the grounds that little has been developed in this area, and there is no available process equipment.

## 6.10 BIOLOGICAL LEACHING

Kilborn does not recommend the installation of this process. Although research has been carried out in this area for many years, it is a batch process, and still at bench scale.

## 6.11 WET BALL MILLING

With regard to the method of pulverizing the coal to provide the feedstack to the deep cleaning section or directly as coal water or coal oil mix, Kilborn recommends wet ball milling in closed circuit with classifying cyclones. Following the survey, it is obvious that wet ball milling is the standard approach for the production of coal water slurry, and is also used in several pilot plants for pulverization before deep cleaning. In order to utilize the space available in the current pilot plant, while still introducing a continuous facility, it will be necessary to crush the 10 millimetre by one millimetre (0.5 millimetre) prior to introducing it with the fine coal into the wet milling circuit. A realistic capacity for operating the wet milling circuit would appear to lie between 1-2 tonnes per hour, depending upon the feed coal characteristics.

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CONTRACT SERIAL NUMBER: OSQ 85-00188

REQUISITION NUMBER: 23440-4-9227

CONTRACTOR: Kilborn Engineering (BC) Ltd

PHASE II and III

EMR : CANMET

EDMONTON COAL RESEARCH LABORATORY

KILBORN PROJECT NO. 7813-15

# DEVELOPMENT AND DESIGN OF A PILOT PLANT FOR DEEP COAL CLEANING

## PHASES II AND III

## REPORT ON FLOWSHEET DEVELOPMENT, ENGINEERING DESIGN AND ESTIMATED COSTS

224 pp

SUBMITTED BY:

KILBORN ENGINEERING (B. C.) LTD.
1380 Burrard Street
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AUG 15 1986
MICROMEDIA

MARCH, 1986

4-9227

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March 27, 1986

Edmonton Coal Research Laboratory
EMR:CANMET
One Oil Patch Drive
Devon, Alberta
TOC 1EO

Attention: Mr. M. W. Mikhail
Project Scientific Authority

Dear Sirs:

Please find enclosed ten (10) copies of the Final Report, entitled:

> 'EMR:CANMET
> EDMONTON COAL RESEARCH LABORATORY
> KILBORN PROJECT NO. 7813-15
> DEVELOPMENT AND DESIGN OF A PILOT PLANT FOR
> DEEP COAL CLEANING - PHASES II AND III
> REPORT ON FLOWSHEET DEVELOPMENT, ENGINEERING DESIGN AND
> ESTIMATED COSTS.'

Accompanying this Report are ten (10) complete sets of Engineering Drawings covering all of the design phases of the Project. The previous report covering the 'Information Collection Stage', which was submitted to you on February 3, 1986, is the companion report for the Project and, together, they form the total Final Report.

We trust that this Report meets with your satisfaction, but if you should have any queries regarding any part of the work carried out by Kilborn, we would be pleased to provide whatever assistance we can to clarify or eradicate such matters.

Yours very truly,

KILBORN ENGINEERING (B. C.) LTD.

for

R. J. Davies, P.Eng.
Project Manager

RJD/mr

EMR : CANMET

EDMONTON COAL RESEARCH LABORATORY

KILBORN PROJECT NO. 7813-15

# DEVELOPMENT AND DESIGN OF A PILOT PLANT FOR DEEP COAL CLEANING

## PHASES II AND III

## REPORT ON FLOWSHEET DEVELOPMENT, ENGINEERING DESIGN AND ESTIMATED COSTS

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# 1.0 INTRODUCTION

# 1.0 INTRODUCTION

The purpose of Phase I of the Project, i.e. Information Collection Stage, was to review the current status of deep coal cleaning and select equipment and circuit options for the proposed Pilot Plant at the Edmonton Coal Research Laboratory (ECRL). Kilborn Engineering (B. C.) Ltd. (Kilborn) completed a report on this phase for Canada Energy, Mines and Resources (EMR), which was issued on March 11, 1986. After reviewing the conclusions of this Survey with ECRL, a Preliminary Flowsheet was produced, containing the following main components:

(a) Coal grinding by wet milling in a closed circuit controlled by classifying cyclones;
(b) Two-stage froth flotation (including reverse flotation);
(c) National Research Council spherical oil agglomeration process;
(d) High gradient magnetic separation for the removal of paramagnetic minerals;
(e) Off-line, high intensity electrical separation for the removal of mineral content;
(f) Centrifugal dewatering of cleaned coal slurry;
(g) Coal-water mixing facilities.

After further review by ECRL, six separate flowsheet options were developed and approved by ECRL, and detailed design was commenced.

The Deep Cleaning Pilot Plant area selected is located adjacent to the existing Coal Cleaning Pilot Plant, and occupies 60 square metres of what was formerly a part of the CMRC Pilot Plant area.

This Report describes the final two phases of the Project, i.e. Phase II - Flowsheet Development, and Phase III - Pilot Plant Design and Capital Cost Estimates. Design considerations are described in the Report as follows:

(a) Basic Concepts;
(b) Flowsheet Development;
(c) Equipment Selection and Specification;
(d) Mechanical Engineering and Layout Design;
(e) Structural, Civil and Piping Design;
(f) Electrical and Instrumentation Design;
(g) Fabrication and Construction Considerations.

This Report, when combined with: the Phase I Report on the Information Collection Stage; all drawings listed in Section 13.0 of this Report and submitted separately; and an indexed file of back-up material covering all three phases of the Project, represents the Final Report for the Project.

# 2.0 SUMMARY

# 2.0 SUMMARY

## 2.1 PHASE I - INFORMATION COLLECTION SURVEY

The conclusions of Phase I are as follows:

(a) A functional deep coal cleaning pilot plant should comprise wet milling, two-stage froth flotation, oil agglomeration, magnetic and electrical separation, and centrifugal dewatering.

(b) The literature survey suggested that great potential exists at the present time for commercializing coal-liquid mixture applications in thermal power generation.

(c) The next logical step in the commercialization process is to build pilot-scale coal preparation and combustion plants to obtain technical and design data.

(d) Certain coal cleaning methods may not be commercially applicable at the high capacities required, e.g. High Gradient Magnetic Separation (HGMS) and High Intensity Electrical Separation (HIES).

## 2.2 PHASE II - FLOWSHEET DESIGN

During the initial period of flowsheet development and conceptual layout work for the Pilot Plant, the optimized capacity of the deep coal cleaning circuit was determined to be 2 tonnes per hour of coal feed to the wet ball mill.

## 2.3 PHASE III - PLANT DESIGN

The final design of the Deep Coal Cleaning Pilot Plant includes all circuits originally proposed in the Preliminary Flowsheet, with the following treatment capacities:

(a) Wet Milling and Cyclone Classification - 2 tonnes per hour average, and up to 4 tonnes per hour maximum;
(b) Froth Flotation - 2 tonnes per hour average, and up to 3 tonnes per hour maximum;
(c) Oil Agglomeration - 2 tonnes per hour average, and up to 3 tonnes per hour maximum;
(d) HGMS - 0.5 tonnes per hour average;
(e) HIES - 0.5 tonnes per hour average - off-line.

Step (e) requires wet milling and froth flotation separation, followed by thermal drying which is contemplated as being carried out in the adjoining CMRC Pilot Plant. The dry coal will then be continuously treated in 2-5 tonne batches by the high intensity electrical separator.

The normal operating arrangement for the new Pilot Plant extension will be to continuously treat, at the rate of 2-tonnes per hour, cleaned coal emanating from the existing Coal Cleaning Pilot Plant, which was designed to operate at between 2 and 10 tonnes per hour capacity. The actual capacity at which the deep cleaning circuits can be operated will depend mainly upon the rate at which the coal can be milled, and the degree of fineness required. The design allows for reasonably wide extremes, but on occasions when very hard coals are encountered, it will be necessary to reduce the capacity to below 2 tonnes per hour in order to achieve the desired fineness of product.

## 2.4 CONSTRUCTION PHASES

Due to the high cost involved in completing the total new Pilot Plant extension, it was agreed with ECRL that the following construction phases would apply:

(a) Phase I - Completion of new plant extension (including steelwork, flooring, concrete foundation and bases, and normal building services); installation of the ball mill, classifying cyclones, drum magnetic separator, dewatering cyclones centrifuge, and coal-water mixing, and storage units; together with associated pumps.

(b) Phase II - Installation of froth flotation and oil agglomeration circuits with reagent pumps, etc.

(c) Phase III - Installation of HGMS and HIES units, together with all pumps and feed systems, etc.

During Phase I, all necessary preparatory work will be completed for the future installation of equipment in subsequent phases.

## 2.5 CAPITAL COST ESTIMATE

The total estimated capital cost for the complete Pilot Plant (all phases of construction) will be $2,305,435. This comprises the following:

| | |
|---|---|
| Excavation, Concrete, Steel and Architectural | $ 132,492 |
| Mechanical, including Equipment and Piping | 1,246,233 |
| Electrical and Instrumentation | 481,971 |
| SUBTOTAL DIRECT COSTS | $ 1,860,696 |
| Construction Indirect Costs | 235,154 |
| Contingency at 10 Percent | 209,585 |
| TOTAL ESTIMATED COST | $ 2,305,435 |

# 3.0 FLOWSHEET DEVELOPMENT

# 3.0 FLOWSHEET DEVELOPMENT

## 3.1 GENERAL

After completion of the Information Survey, a Preliminary Flowsheet was developed to include the following components:

(a) Coal crushing from 10 millimetres (as received from the existing Pilot Plant) to 2 millimetres, in one stage;
(b) Coal grinding, wet milling in a closed circuit controlled by classifying cyclones;
(c) Two-stage froth flotation (including reverse flotation);
(d) Spherical oil agglomeration;
(e) High Gradient Magnetic Separation (HGMS);
(f) High Intensity Electrical Separator (HIES) (of dry coal in an off-stream unit);
(g) Centrifugal dewatering of cleaned coal slurry;
(h) Coal-water mixing system.

This Preliminary Flowsheet (Drawing No. 100-10-13) is included in Section 13.0 for reference purposes.

These components were selected on the basis of the following considerations:

(a) Current research and development work in ultrafine or deep coal cleaning [i.e. minus 325 mesh (45 microns)];
(b) Current research and development work in coal-water mixture preparation, with particular reference to wet milling;
(c) Currently employed equipment in existing deep coal cleaning and coal-water mixture preparation pilot plants.

The Preliminary Flowsheet indicated that the deep cleaning section would normally be an integral part of the existing

Pilot Plant facilities and, as such, the combined Pilot Plant could be operated to accommodate a large number of alternatives. The initially cleaned coal product would comprise coarse and fine components obtained from various alternative combinations of Batac jig, heavy media cyclone, and coarse coal water-only cyclone with fine coal water-only cyclone, and/or froth flotation. Subsequent deep cleaning alternatives of froth flotation and/or oil agglomeration provide the potential for maximizing ash content removal to obtain exceptionally low ash products from certain types of coal. Such products then become achievable, using familiar but highly controlled coal cleaning equipment in an unprecedented type of pilot plant. With the addition of reverse flotation, HGMS and HIES as alternative processes for the removal of sulphur containing minerals, the further capability of reducing the environmental hazard of coal combustion is available. This is of special significance in treating eastern Canadian high sulphur coals where combustion is a recognized hazard.

## 3.2 PROCESS OPTION SELECTION

The specific process options selected for the Deep Coal Cleaning Pilot Plant, in conjunction with the Scientific Authority, are as follows:

(a) Froth Flotation - Two-cell banks each comprising three double-cell flotation machines. These two banks can be arranged in three ways:

  i) Rougher/cleaner: where the cleaned coal concentrates product from the first bank is diluted with water and recleaned in the second bank;

  ii) Two-stage: where the tailings product from the first bank is retreated after conditioning in the second bank;

iii) Reverse system: where the cleaned coal concentrates product from the first bank is depressed and pyrite is floated in the second bank.

(b) Spherical Oil Agglomeration - Based on the NRC method, comprising two-stage mixing with optional screening and pelletizing of the agglomerated product.

(c) High Gradient Magnetic Separation - Comprising a single unit able to treat up to 0.5 tonnes per hour ultra-fine coal slurry.

(d) High Intensity (or Electrostatic) Separation - Comprising a single unit able to treat up to 0.2 tonnes per hour of bone dry, ultra-fine coal. This separator must be operated in a non-oxidizing, ionizing atmosphere (carbon dioxide is recommended) to prevent combustion from occurring during or after separation.

The possible inclusion of some form of chemical cleaning process had been investigated during the Information Survey. This had been rejected due to the specialized process requirements involved, and the prohibitive cost anticipated for a pilot plant capacity of 2-5 tonnes per hour as requested by the Scientific Authority.

## 3.3 BASIC DESIGN CRITERIA

### 3.3.1 Plant Location

Formal design criteria were not specified by the Scientific Authority at the outset of the Project because it was realized that numerous constraints existed, which would influence the capacity and potential flexibility of the plant. The most serious of these was space available within the existing Pilot Plant area.

With the negotiation and subsequent consent from CMRC for part of their adjacent Pilot Plant area, the constraint imposed by limited space was largely eliminated, and it was possible to proceed with a design at a capacity of 2 tonnes per hour, incorporating all of the desired process components.

### 3.3.2 Design Criteria

The following general criteria were used in the design work, described later in this section of the Report:

Plant Feed Capacity - 2 tonnes per hour (nominal) to be reduced for very hard coals and increased for soft coals to a maximum of 3 tonnes per hour.

Feed Coal - Cleaned coal sized 10 mm by zero from:
- (a) Any combination of circuits in the existing pilot plant;
- (b) Coal stored in steel drums.

Feed Coal Moisture - 10 mm by zero component at up to 15% surface moisture mixed with 0.5 mm by zero slurry at up to 25% solids by weight.

Feed Coal Quality - All ranks of hard coal ranging in Hardgrove Grindability Index from 60 to 80 normally, but extending to as low as 35 and as high as plus 100. Ash contents normally ranging from 5-15% (air-dry). Sulphur-contents ranging from 0.5-5.0% (air-dry).

The following process criteria were used for the design work:

Plant Yield - Due to the fact that cleaned coal will be treated; yields from the deep coal cleaning plant will normally be high, i.e. plus 80%. Some loss of potential product will occur in thickening and dewatering; possibly 2-8% by weight.

Coal Crushing - 95% passing 2 mm or finer.

Coal Milling - 95% passing 45 mm or finer.

Classifying Cyclones - $d_{50}$ = 25 mm.

Thickening Cyclones - $d_{50}$ = 5 mm.

Flotation Cells - 5-10% feed solids concentration; 5 minutes retention time per bank.

Spherical Agglomeration - 10-20% feed solids concentration, NRC process design only.

Solid Bowl Centrifuge - 40% maximum water content in cake product (by weight);
- 98% minimum solids recovery.

Coal-Water Mixture - 65-80% coal content by weight.

Additional, more specific, design criteria were incorporated into the Performance Specifications included in Appendix 'C' of this Report. Due to limitations in treatment capacity of the HGMS, the Pilot Plant will be limited to a maximum throughput of 0.5 tonnes per hour.

Because of the need to thermally dry the wet milled, beneficiated coal product, prior to treatment by the HIES, this unit has been designed as an off-line process which will batch-treat the dry powdered coal at a rate up to 0.2 tonnes per hour.

## 3.4 FLOWSHEET DESIGN AND DESCRIPTION

Cleaned coal sized 10 millimetres to zero is produced at up to 2 tonnes per hour by the existing Coal Cleaning Pilot Plant. Any existing flowsheet option can be employed to produce this cleaned coal with influence upon the Deep Cleaning Pilot Plant circuits. Alternatively, samples of coal stored in drums can be introduced at the same feed point to the Deep Coal Cleaning Pilot Plant and at the same feed rate.

The design capacity of the Deep Coal Cleaning Pilot Plant is 2 tonnes per hour, but this may be increased to 3 tonnes per hour if soft or friable coal is treated. Conversely, it may prove necessary to reduce the feed capacity to as low as one tonne per hour in order to effectively grind very hard coal. The normal range of Hardgrove Grindability Index likely to result in an average milling capacity of 2 tonnes per hour is 60 to 80.

Under normal circumstances, the total Pilot Plant will be operated to produce coal-water slurries of 65-80 percent solids concentration by weight at a rate of between 1.5 to 2 tonnes per hour. Cleaned coal from the existing HM cyclone clean coal drain and rinse screen gravitates to a hammermill which reduces the top size from 10 millimetres to 2 millimetres.

The crushed coal is joined by fine clean coal emanating from the fines treatment circuit(s) of the existing Pilot Plant beneath the crusher, and gravitates into the ball mill feed pump box.

If necessary, clarified water may be added to this pump box in response to the density signal from the density gauge located on the delivery pipeline to the ball mill. Normally, a very small quantity of water will be required to maintain the required feed solids concentration of about 50 percent solids by weight.

A 1.83-metre diameter by 3.66-metre long rubber lined ball mill, fitted with a discharge trommel, is employed for milling the coal. This ball mill was selected for a proven capability to produce ultra-fine coal sized 80 percent minus 22 microns at a feed capacity of 2 tonnes per hour. This degree of size reduction corresponds to a coal having a Bond Work Index of 15 - which is a characteristic value for high volatile bituminous coal and some semi-anthracite coal. Fresh coal, after the first pass through the mill, is pumped to 4-125 millimetres diameter classifying cyclones which normally separate at a $d_{50}$ cut-size of between 20 and 25 microns. The underflow from the classifying cyclones gravitates to the ball mill feed for regrinding. The overflow passes either to the beneficiation circuits or to the thickening cyclones.

The ball mill has been sized for a normal circulating load ratio of 300 percent. This may be exceeded to almost 400 percent without the need to reduce the fresh coal feed rate. A build-up in circulating load is carefully monitored by signals obtained from the flow rate and density gauge devices located on the classifying cyclone feed line. In addition, several sampling points have been included in the design to facilitate regular manual checking during the stabilization period of 15-20 minutes after plant start-up.

The overflow is likely to contain traces of magnetite (from the HM cyclone circuits) and some finely sized iron and steel from the ball mill. These impurities are removed by a wet drum magnetic separator located in the classifying cyclone overflow stream. This material is collected in drums for use as media in the HM cyclone circuit. The various flowsheet options, following milling, are described in Section 3.5. The overall flowsheet is shown in Figure 3.01 (Drawing No. 100-10-01).

## 3.5 FLOWSHEET OPTIONS

There are eight separate flowsheet options which include a further 6-8 suboptions (not including pre-deep coal cleaning circuit options which may be selected in the existing Pilot Plant).

The eight main flowsheet options, as selected by the Scientific Authority, are as follows:

| Flowsheet Option No. | Title | Figure No. | Kilborn Dwg. No. |
|---|---|---|---|
| 1. | Coal Grinding Only | 3.02 | 100-10-05 |
| 2. | Two-Stage Flotation | 3.03 | 100-10-06 |
| 3. | Reverse Flotation | 3.04 | 100-10-07 |
| 4. | Oil Agglomeration | 3.05 | 100-10-08 |
| 5. | Oil Agglomeration/Flotation | 3.06 | 100-10-09 |
| 6. | Flotation/Oil Agglomeration | 3.07 | 100-10-10 |
| 7. | HGMS Cleaning/Two-Stage Flotation | 3.08 | 100-10-11 |
| 8. | Two-Stage Flotation/HIES Cleaning | 3.09 | 100-10-12 |

### 3.5.1 Coal Grinding Only (See Figure 3.02)

The coal grinding option employs all the equipment previously described together with the 16-50 millimetre diameter thickening cyclones which prepare a slurry of minimum 30 percent solids content by weight, which is then pumped to the 457 millimetre diameter by 1372 millimetre long solid bowl centrifuge. The centrifuge, without the aid of flocculant, produces a mud with about 60 percent solids, and recovers at least 98 percent of the solids from the original feed (Ref. 1).

The centrifuge mud gravitates to a coal-water mixing box into which stabilizing agents are added. With low-speed agitation from an impeller within the tank, the final mixture is produced continuously and the slurry is discharged into a 2-tonne bin for loading into barrels.

### 3.5.2 Two-Stage Flotation (See Figure 3.03)

For this option, the classifying cyclone passes to the conditioning tank of the primary flotation cell bank via the wet drum magnetic separator which removes any ferro-magnetic material. After a residence time of about 90 seconds, the slurry passes to the primary cell bank which comprises six minus 0.6 cubic metre flotation cells arranged in pairs. The normal retention time for the feed slurry at about 5 percent solids concentration by weight will be between 4 and 5 minutes. If this is insufficient, the tailings can be directed to the conditioner of the secondary cell bank which is identical to the primary, and residence time is, therefore, doubled. The operating conditions used to design this circuit are very similar to those used for another coal-water pilot plant (Ref. 2), and in ultra-fine coal flotation research work conducted in Canada (Ref. 3).

The alternative to two-stage flotation is to employ the rougher-cleaner arrangement. For this suboption, the flotation concentrate obtained from the primary cell bank is pumped to the conditioning tank preceding the secondary cell bank.

This slurry is then recleaned with the subsequent tailings being pumped back to the primary cell bank. To employ this suboption, the feed capacity of the Deep Coal Cleaning Pilot Plant may be reduced to accommodate the recirculation of these tailings, but for fast floating coal, it may still be possible to operate the plant at close to the normal rated 2 tonnes per hour.

### 3.5.3 Reverse Flotation (See Figure 3.04)

The operation of this option involves the same equipment as the rougher-cleaner system, except that when the coal concentrate reaches the secondary cell bank conditioning tank, different reagents are employed. A depressing agent causes the coal to be depressed, and a xanthate-type of reagent is employed as a collector for iron sulphide mineral collection.

This circuit is essentially the same as that employed at the Research and Development Laboratories of the United States Bureau of Mines of the DOE (Ref. 4). Because the 'tailings' product from the secondary cell bank contains the required clean coal, it is necessary to thicken this slurry to meet the feed slurry criteria of the solid bowl centrifuge. The underflow slurry concentration required from the thickening cyclones is about 30 percent solids by weight.

### 3.5.4 Oil Agglomeration (See Figure 3.05)

The classifying cyclone overflow will normally be too dilute to be routed directly to the oil agglomeration circuit, and it will first be necessary to pump this slurry to the thickening cyclones to obtain a slurry with between 15 and 25 percent solids concentration by weight. This is then pumped to the high shear in-line mixer, and the agglomerating agents (e.g. light oil plus diesel emulsion) are pumped in at the same point. The agglomerated slurry then passes to the low-speed (shear) mixer in which the agglomerates become consolidated and settle within the vessel. Two discharge options exist:

(a) The agglomerated slurry can be pumped either to the solid bowl centrifuge or the flotation circuit to be further upgraded into a coal-water mixer, or
(b) The agglomerated slurry can be gravitated to a 1.22-metre diameter gyratory sieve for dewatering and then to a 1.83-metre diameter pelletizing disc.

This circuit has been designed according to instructions received from Dr. C. E. Capes of the National Research Council of Canada (NRC), and is the result of over 10 years of development (Ref. 5). This work has recently culminated in the first commercial applications of the process.

### 3.5.5 Oil Agglomeration/Single-Stage Flotation (See Figure 3.06)

This option has been included at the request of the Scientific Authority following the recommendation of Dr. C. E. Capes. The agglomerated slurry emanating from the low-speed mixer is pumped to conditioning tank of the primary flotation cell bank. The presence of the oil on the surface of the coal serves to create excellent conditions for collection, and only a short flotation time (1-2 minutes) is really required to float the coal (Ref. 6).

### 3.5.6 Single-Stage Flotation/Oil Agglomeration (See Figure 3.07)

This option has been included at the request of the Scientific Authority to add further flexibility to the Pilot Plant. Froth flotation concentrates at about 20 percent solids by weight are pumped to the high shear in-line mixer for agglomeration. Once again, the option exists for the agglomerated product to be either dewatered by the solid-bowl centrifuge or by the gyratory screen, and either dewatered product may be pelletized using the pelletizing disc to which a heated binder oil is usually added at a low dosage in order to obtain the most resilient pellets.

### 3.5.7 High Gradient Magnetic Separation/Two-Stage Flotation

(See Figure 3.08)

As an alternative to the reverse flotation option for removing sulphur, the High Gradient Magnetic Separator (HGMS) is employed following the wet drum magnetic separator which removes all ferro-magnetic fines from the slurry. This pre-treatment is essential prior to the HGMS, because the iron particles coagulate in the filament matices of the separator causing localized plugging and eventual blockage which is often difficult to clean out (Ref. 7).

The current design is to accommodate a recently developed high intensity separator with a new grid wire matrix. This was selected instead of the much more expensive HGMS which contains a patented window tunnel containing an extremely fine filament matrix. Because of the very fine diameter of the filaments, the magnetic gradient that can be achieved is up to 300 times greater than that with fine metal plates. The newer wire matrix which is available with the high intensity unit, brings it closer to the HGMS in that it is able to recover at least 75 percent of pyrite grains sized below 20 microns, which the HGMS unit has been able to remove. Both units are still undergoing research and development work to improve performance with coal-pyrite separation.

After pyrite removal, the slurry is pumped to the conditioning tank of the primary flotation cell bank. Either single- or double-stage cleaning can then be carried out to remove other incombustibles from the coal prior to dewatering, using the centrifuge and coal-water mixture preparation.

### 3.5.8 High Intensity (Electrostatic) Separation (See Figure 3.09)

For convenience, Kilborn has shown this separator in a circuit employing the two-stage, froth flotation system because it is believed to represent the most effective alternative for preparing a cleaned coal which is amenable to thermal drying. If oil agglomeration was selected instead, the presence of oil in an agglomerated fine product may lead to binding during the thermal drying process, thereby necessitating some form of attrition to obtain the free-running powder necessary for good electrical separation. The combination of froth flotation and centrifugal dewatering is thought unlikely to result in a dried product containing lumps, but ECRL proposes to investigate this material in due course.

### 3.5.9 Tailings Treatment and Process Water

All tailings or effluent flow emanating from the coal cleaning circuits of the Deep Coal Cleaning Pilot Plant will be routed to the existing Envirotech High Capacity Thickener. Clarified water from this thickener will be distributed as process water to the new section. Raw water, from the main water supply, will be used only for reagent mixing and dilution purposes and for control equipment. However, it may be advisable to install an extra incoming supply of raw water to fully meet the needs of the new plant, and to cater for future expansion of the existing plant.

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5. C. E. Capes, 'Oil Agglomeration for Fine Coal Processing.' 4th Symposium on Agglomeration, Toronto, June 1985.

6. C. E. Capes, 'Notes on NRC Oil Agglomeration Circuit.' February 27, 1986. (See Appendix 'F').

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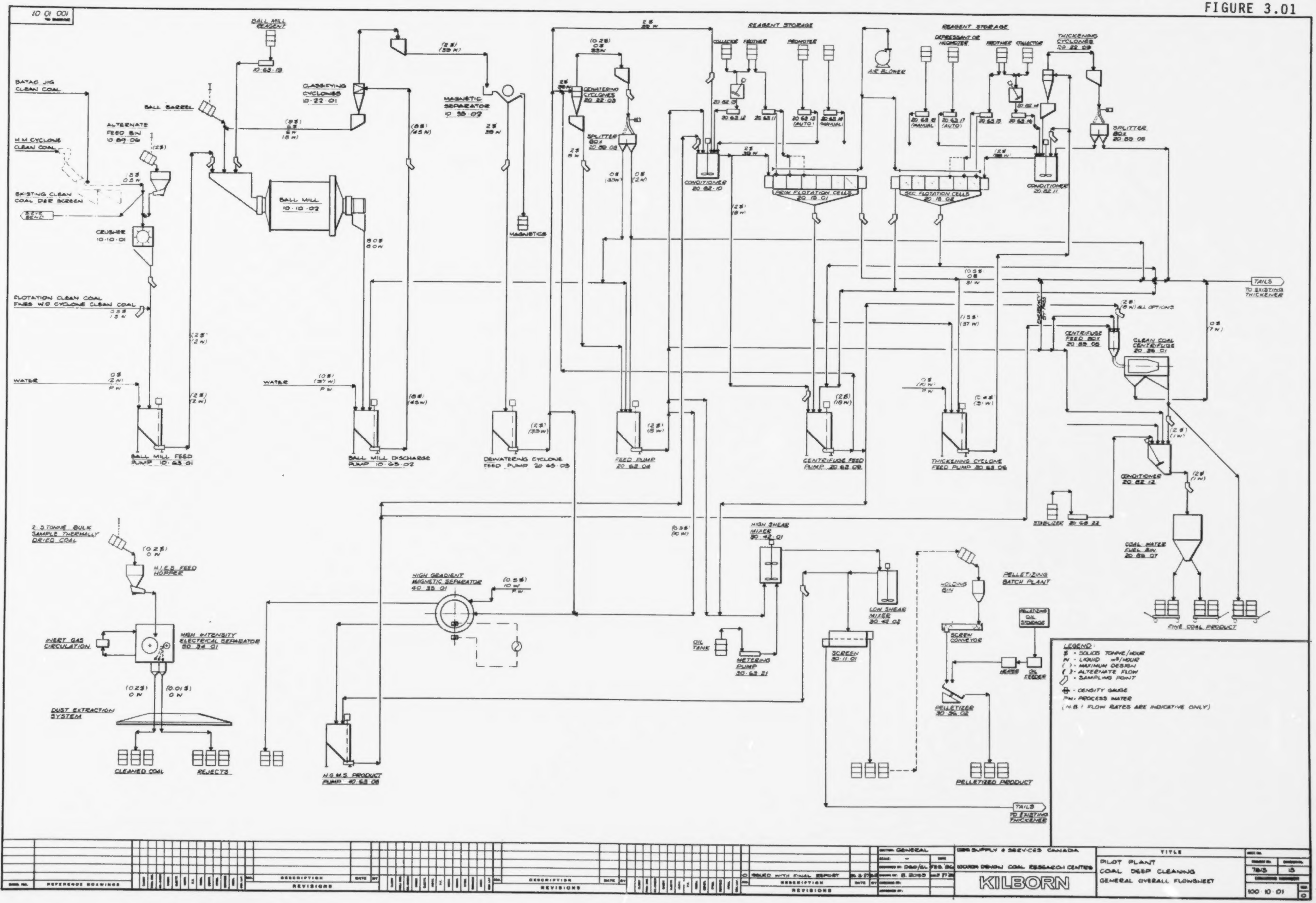
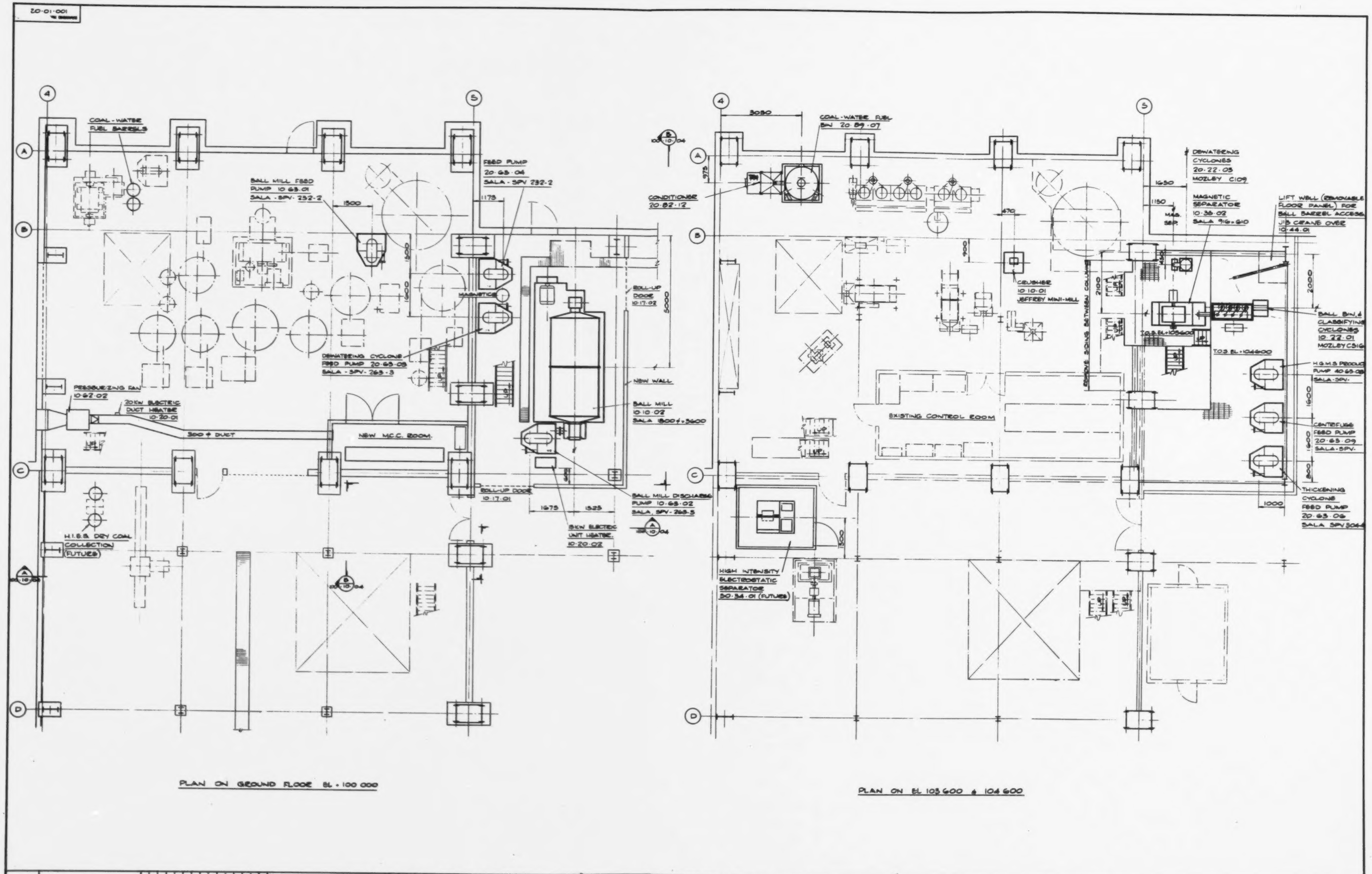
FIGURE 3.01


10 01 001
BATAC JIG CLEAN COAL
H.M. CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
ALTERNATE FEED BIN 10 89 06
BALL BARREL
BALL MILL REAGENT
10-63-13
CRUSHER 10-10-01
FLOTATION CLEAN COAL FINES W.O CYCLONE CLEAN COAL
WATER
BALL MILL FEED PUMP 10-63-01
CLASSIFYING CYCLONES 10-22-01
BALL MILL 10-10-02
BALL MILL DISCHARGE PUMP 10-63-02
MAGNETIC SEPARATOR 10 35 02
MAGNETICS
DEWATERING CYCLONE FEED PUMP 20 63 03
DEWATERING CYCLONES 20 22 03
SPLITTER BOX 20 89 03
FEED PUMP 20 63 04
REAGENT STORAGE
COLLECTOR
FROTHER
PROMOTER
DEPRESSANT OR PROMOTER
AIR BLOWER
CONDITIONER 20 82 10
PRIM FLOTATION CELLS 20 15 01
SEC FLOTATION CELLS 20 15 02
CONDITIONER 20 82 11
THICKENING CYCLONES 20 22 09
SPLITTER BOX 20 89 05
(AUTO)
(MANUAL)
TAILS TO EXISTING THICKENER
CENTRIFUGE FEED BOX 20 89 06
CLEAN COAL CENTRIFUGE 20 36 01
ALL OPTIONS
CENTRIFUGE FEED PUMP 20 63 08
THICKENING CYCLONE FEED PUMP 20 63 06
CONDITIONER 20 82 12
STABILIZER 20 63 22
COAL WATER FUEL BIN 20 89 07
FINE COAL PRODUCT
2 STONNE BULK SAMPLE THERMALLY DRIED COAL
H.I.E.S. FEED HOPPER
INERT GAS CIRCULATION
HIGH INTENSITY ELECTRICAL SEPARATOR 30 34 01
DUST EXTRACTION SYSTEM
CLEANED COAL
REJECTS
HIGH GRADIENT MAGNETIC SEPARATOR 40 35 01
H.G.M.S. PRODUCT PUMP 40 63 08
HIGH SHEAR MIXER 30 42 01
LOW SHEAR MIXER 30 42 02
OIL TANK
METERING PUMP 30 63 21
SCREEN 30 11 01
HOLDING BIN
PELLETIZING BATCH PLANT
SCREEN CONVEYOR
PELLETIZING OIL STORAGE
HEATER
OIL FEEDER
PELLETIZER 30 36 02
PELLETIZED PRODUCT
LEGEND:
$ - SOLIDS TONNE/HOUR
W - LIQUID m³/HOUR
( ) - MAXIMUM DESIGN
( ) - ALTERNATE FLOW
- SAMPLING POINT
- DENSITY GAUGE
PW - PROCESS WATER
(N.B.! FLOW RATES ARE INDICATIVE ONLY)
REFERENCE DRAWINGS
DESCRIPTION
REVISIONS
0 ISSUED WITH FINAL REPORT
SECTION GENERAL
DESIGNED BY: DGD/GL FEB '86
DRAWN BY: B. ROSS
DSS SUPPLY & SERVICES CANADA
LOCATION DEVON COAL RESEARCH CENTRE
KILBORN
TITLE
PILOT PLANT
COAL DEEP CLEANING
GENERAL OVERALL FLOWSHEET
7813
13
100 10 01
0


20-01-001
COAL-WATER FUEL BARRELS
BALL MILL FEED PUMP 10-63-01 SALA-SPV-232-2
FEED PUMP 20-63-04 SALA-SPV 232-2
1500
1175
MAGNETICS
DEWATERING CYCLONE FEED PUMP 20-63-03 SALA-SPV-263-3
ROLL-UP DOOR 10-17-02
5000
NEW WALL
BALL MILL 10-10-02 SALA 1800⌀ x 3600
PRESSURIZING FAN 10-62-02
20KW ELECTRIC DUCT HEATER 10-20-01
300⌀ DUCT
NEW M.C.C. ROOM
ROLL-UP DOOR 10-17-01
1675
1525
BALL MILL DISCHARGE PUMP 10-63-02 SALA-SPV-263-3
15KW ELECTRIC UNIT HEATER 10-20-02
H.I.E.S. DRY COAL COLLECTION (FUTURE)
PLAN ON GROUND FLOOR EL. 100 000
3050
COAL-WATER FUEL BIN 20-89-07
CONDITIONER 20-82-12
975
470
900
CRUSHER 10-10-01 JEFFREY MINI-MILL
REMOVE SIDING BETWEEN COLUMNS
2100
1650
1150
MAG. SEP.
DEWATERING CYCLONES 20-22-03 MOZLEY C109
MAGNETIC SEPARATOR 10-38-02 SALA 916-G10
LIFT WELL (REMOVABLE FLOOR PANEL) FOR BALL BARREL ACCESS. JIB CRANE OVER 10-44-01
2000
BALL BIN & CLASSIFYING CYCLONES 10-22-01 MOZLEY C316
T.O.S. EL. 103600
T.O.S. EL. 104600
H.G.M.S. PRODUCT PUMP 40-63-03 SALA-SPV-
1600
EXISTING CONTROL ROOM
CENTRIFUGE FEED PUMP 20-63-09 SALA-SPV-
1600
800
THICKENING CYCLONE FEED PUMP 20-63-06 SALA SPV 504-
1000
1500
HIGH INTENSITY ELECTROSTATIC SEPARATOR 30-34-01 (FUTURE)
UP
PLAN ON EL 103 600 & 104 600
A
B
C
D
4
5
A 10-10-04
B 10-10-04

100-10-04 GENERAL ARGT. SECTIONS.
100-10-03 GENERAL ARGT. PLAN.
100-10-01 GENERAL BALL FLOWSHEET.
REFERENCE DRAWINGS

D ISSUED WITH FINAL REPORT
C COAL-WATER FUEL RELOCATED
B GENERAL REVISIONS
A ISSUED FOR INFORMATION
DESCRIPTION
REVISIONS

GENERAL
SCALE 1:50
D.G.S.
R.C.

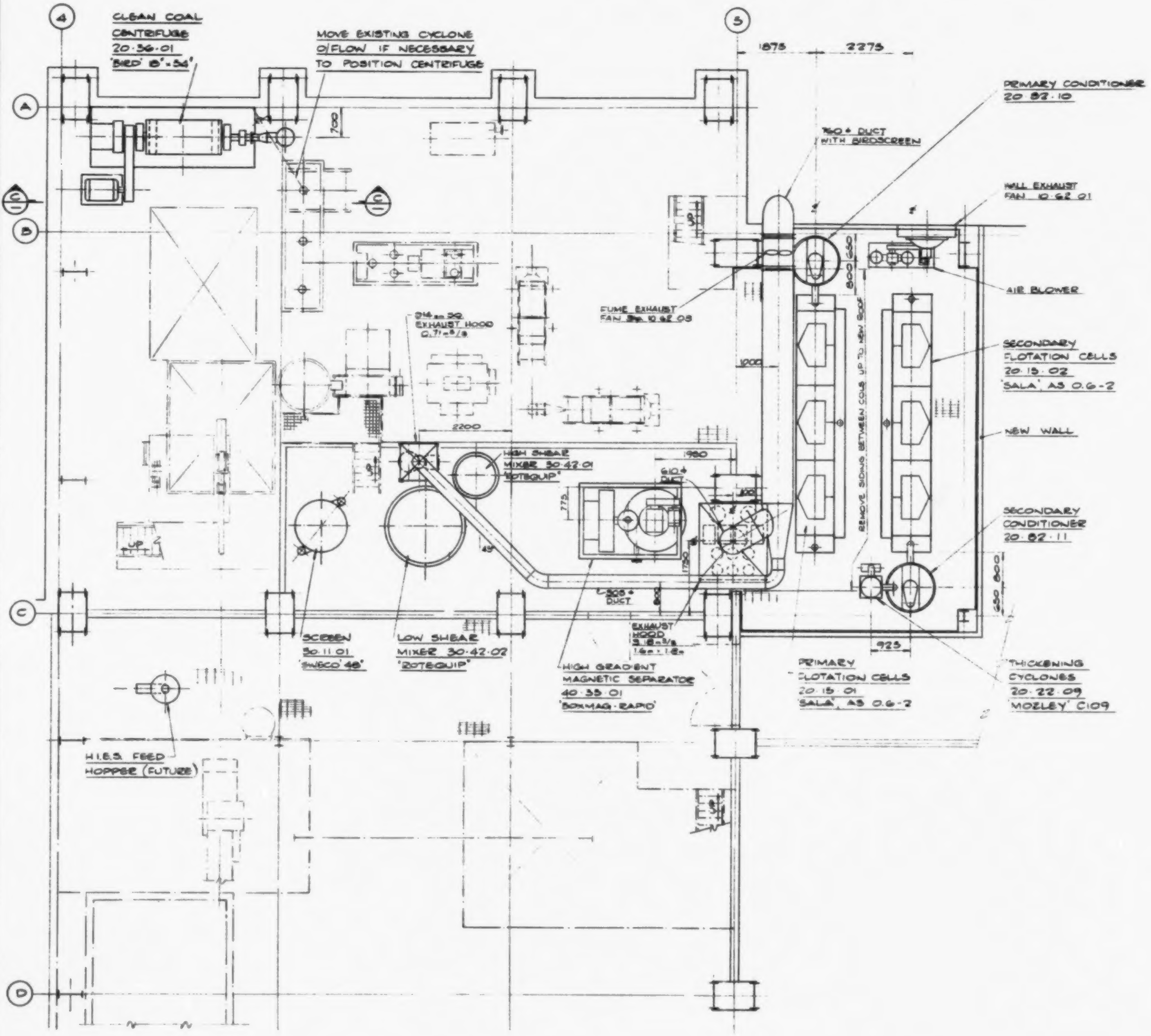
DSS SUPPLY & SERVICES CANADA.
NORDON DEVON COAL RESEARCH CENTRE

KILBORN

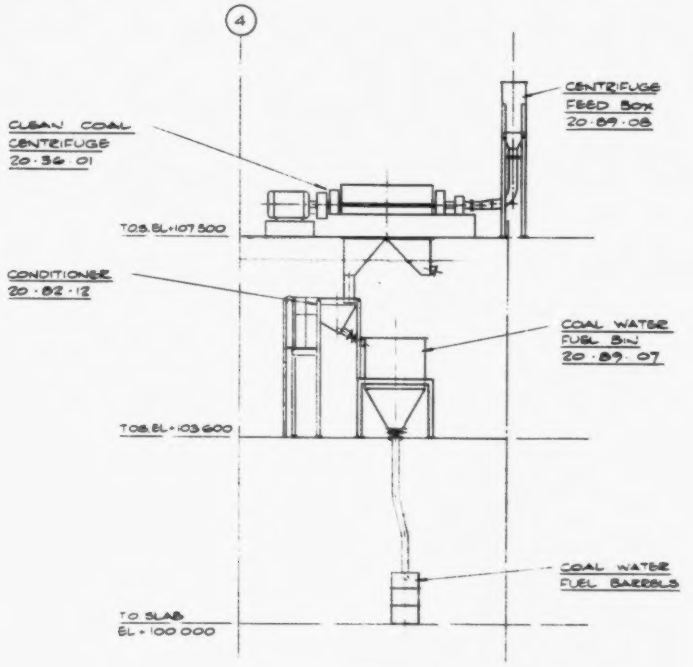
TITLE
PILOT PLANT
COAL DEEP CLEANING
GENERAL ARRANGEMENT - PLANS

7813
13
100-10-02
D

80·01·001


4
5
A
B
C
D
CLEAN COAL CENTRIFUGE 20·36·01 'BIRD' 18" × 56"
MOVE EXISTING CYCLONE O/FLOW IF NECESSARY TO POSITION CENTRIFUGE
1875
2275
700
PRIMARY CONDITIONER 20·82·10
760 ϕ DUCT WITH BIRDSCREEN
WALL EXHAUST FAN 10·62·01
AIR BLOWER
FUME EXHAUST FAN 10·62·03
914 mm SQ. EXHAUST HOOD 0.71 m³/s
1200
REMOVE SIDING BETWEEN COLS. UP TO NEW ROOF
SECONDARY FLOTATION CELLS 20·15·02 'SALA' AS 0.6-2
NEW WALL
2200
HIGH SHEAR MIXER 30·42·01 'ROTEQUIP'
1980
610 ϕ DUCT
100
775
45°
1750
305 ϕ DUCT
800
SECONDARY CONDITIONER 20·82·11
250
800
EXHAUST HOOD 3.18 m³/s 1.6m × 1.2m
SCREEN 30·11·01 'SWECO' 48"
LOW SHEAR MIXER 30·42·02 'ROTEQUIP'
HIGH GRADIENT MAGNETIC SEPARATOR 40·35·01 'BOXMAG-RAPID'
925
PRIMARY FLOTATION CELLS 20·15·01 'SALA' AS 0.6-2
THICKENING CYCLONES 20·22·09 'MOZLEY' C109
H.I.E.S. FEED HOPPER (FUTURE)

PLAN ON EL 107 500


4
CENTRIFUGE FEED BOX 20·89·08
CLEAN COAL CENTRIFUGE 20·36·01
T.O.S. EL+107 500
CONDITIONER 20·82·12
COAL WATER FUEL BIN 20·89·07
T.O.S. EL+103 600
COAL WATER FUEL BARRELS
TO SLAB EL+100 000

SECTION C

| DWG. No. | REFERENCE DRAWINGS |
|---|---|
| 100·10·04 | GENERAL ARR'T. SECTIONS. |
| 100·10·02 | GENERAL ARR'T. PLANS. |
| 100·10·01 | GENERAL O/ALL FLOWSHEET |

REVISIONS

| No. | DESCRIPTION | DATE | BY |
|---|---|---|---|
| O | ISSUED WITH FINAL REPORT | [illegible] | [illegible] |
| C | CENTRIFUGE RELOCATED | [illegible] | RC |
| B | GENERAL REVISIONS | 27 FEB '86 | RC |
| A | ISSUED FOR INFORMATION | FEB '86 | RC |

SECTION: GENERAL
SCALE: 1 : 50
DESIGNED BY: D.G.C. FEB. '86
DRAWN BY: P.C. FEB. '86
CHECKED BY: B. DOBB [illegible]
APPROVED BY:

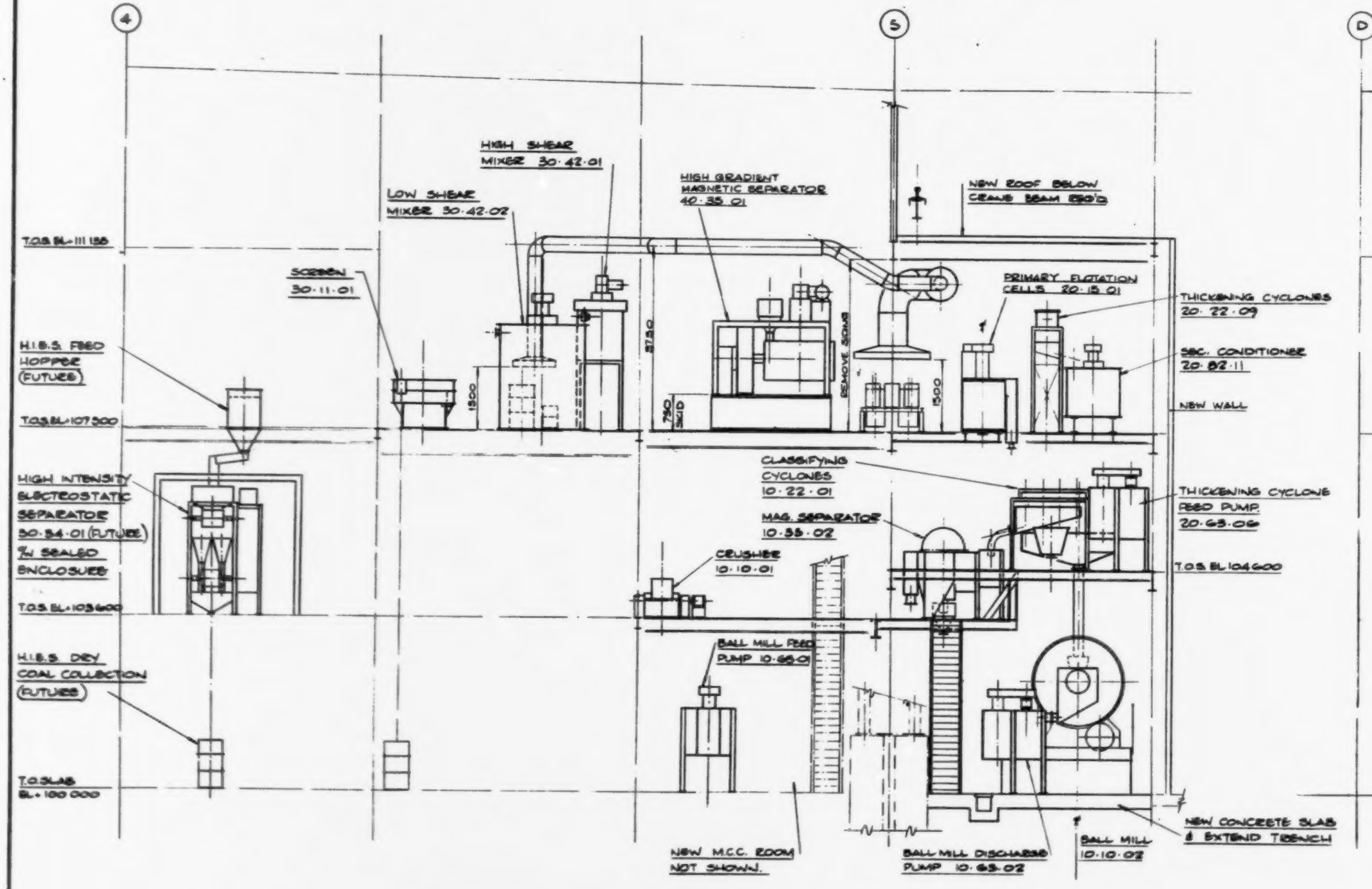
DEPT. SUPPLY & SERVICES CANADA
LOCATION: DEVON COAL RESEARCH CENTRE

KILBORN

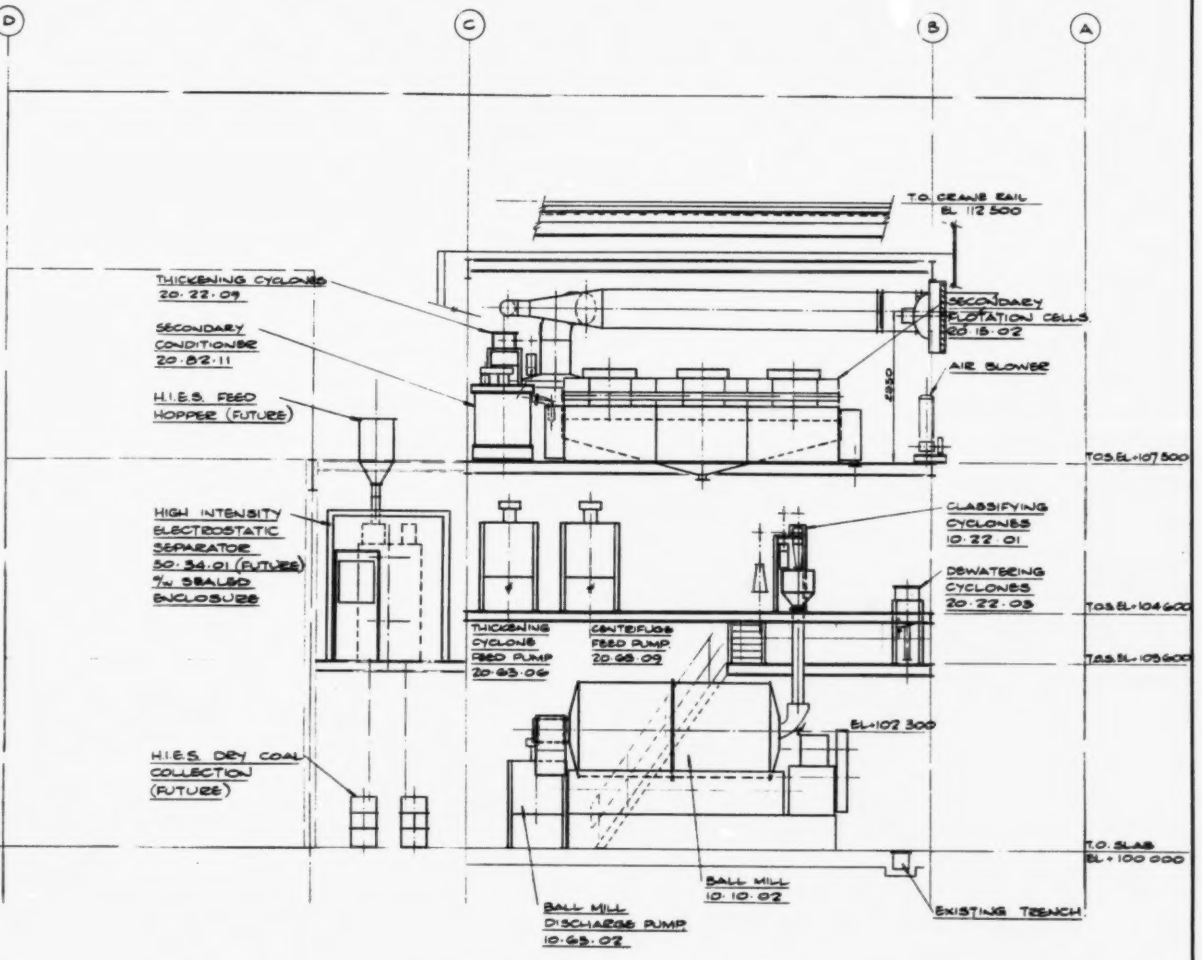
TITLE
PILOT PLANT
COAL DEEP CLEANING
GENERAL ARRANGEMENT - PLAN

PROJECT No. 7813
DRAWING No. 15
DRAWING NUMBER 100·10·03
REV. O

100-01-001
TO DRAWING


4
5
D
HIGH SHEAR MIXER 30·42·01
LOW SHEAR MIXER 30·42·02
HIGH GRADIENT MAGNETIC SEPARATOR 40·35·01
NEW ROOF BELOW CRANE BEAM 850'D
T.O.S. EL-111 155
SCREEN 30·11·01
PRIMARY FLOTATION CELLS 20·15·01
THICKENING CYCLONES 20·22·09
SEC. CONDITIONER 20·82·11
H.I.E.S. FEED HOPPER (FUTURE)
2750
1800
750
3610
REMOVE 30NM
1500
NEW WALL
T.O.S. EL-107 300
HIGH INTENSITY ELECTROSTATIC SEPARATOR 30·34·01 (FUTURE) C/W SEALED ENCLOSURE
CLASSIFYING CYCLONES 10·22·01
MAG. SEPARATOR 10·35·02
THICKENING CYCLONE FEED PUMP 20·63·06
CRUSHER 10·10·01
T.O.S. EL-104 600
T.O.S. EL-103 600
BALL MILL FEED PUMP 10·63·01
H.I.E.S. DRY COAL COLLECTION (FUTURE)
T.O. SLAB EL-100 000
NEW M.C.C. ROOM NOT SHOWN.
BALL MILL DISCHARGE PUMP 10·63·02
BALL MILL 10·10·02
NEW CONCRETE SLAB & EXTEND TRENCH

SECTION A 100-10-02


C
B
A
T.O. CRANE RAIL EL 112 500
THICKENING CYCLONE 20·22·09
SECONDARY CONDITIONER 20·82·11
SECONDARY FLOTATION CELLS 20·15·02
H.I.E.S. FEED HOPPER (FUTURE)
AIR BLOWER
2850
T.O.S. EL-107 300
HIGH INTENSITY ELECTROSTATIC SEPARATOR 30·34·01 (FUTURE) C/W SEALED ENCLOSURE
CLASSIFYING CYCLONES 10·22·01
DEWATERING CYCLONES 20·22·03
T.O.S. EL-104 600
T.O.S. EL-103 600
THICKENING CYCLONE FEED PUMP 20·63·06
CENTRIFUGE FEED PUMP 20·68·09
EL-102 300
H.I.E.S. DRY COAL COLLECTION (FUTURE)
T.O. SLAB EL-100 000
BALL MILL 10·10·02
BALL MILL DISCHARGE PUMP 10·63·02
EXISTING TRENCH

SECTION B 100-10-02

| DWG. No. | REFERENCE DRAWINGS |
|---|---|
| 100-10-03 | GENERAL ARRANGEMENT PLAN |
| 100-10-02 | GENERAL ARRANGEMENT PLAN |
| 100-10-01 | GENERAL O/ALL FLOWSHEET |

| No. | DESCRIPTION | DATE |
|---|---|---|
| D | ISSUED WITH FINAL REPORT | [illegible] |
| C | COAL WATER S/N REMOVED. | [illegible] |
| B | GENERAL REVISION | [illegible] |
| A | ISSUED FOR INFORMATION | FEB '86 |

REVISIONS

GENERAL
SCALE 1:50
DRAWN BY P.C. FEB 86

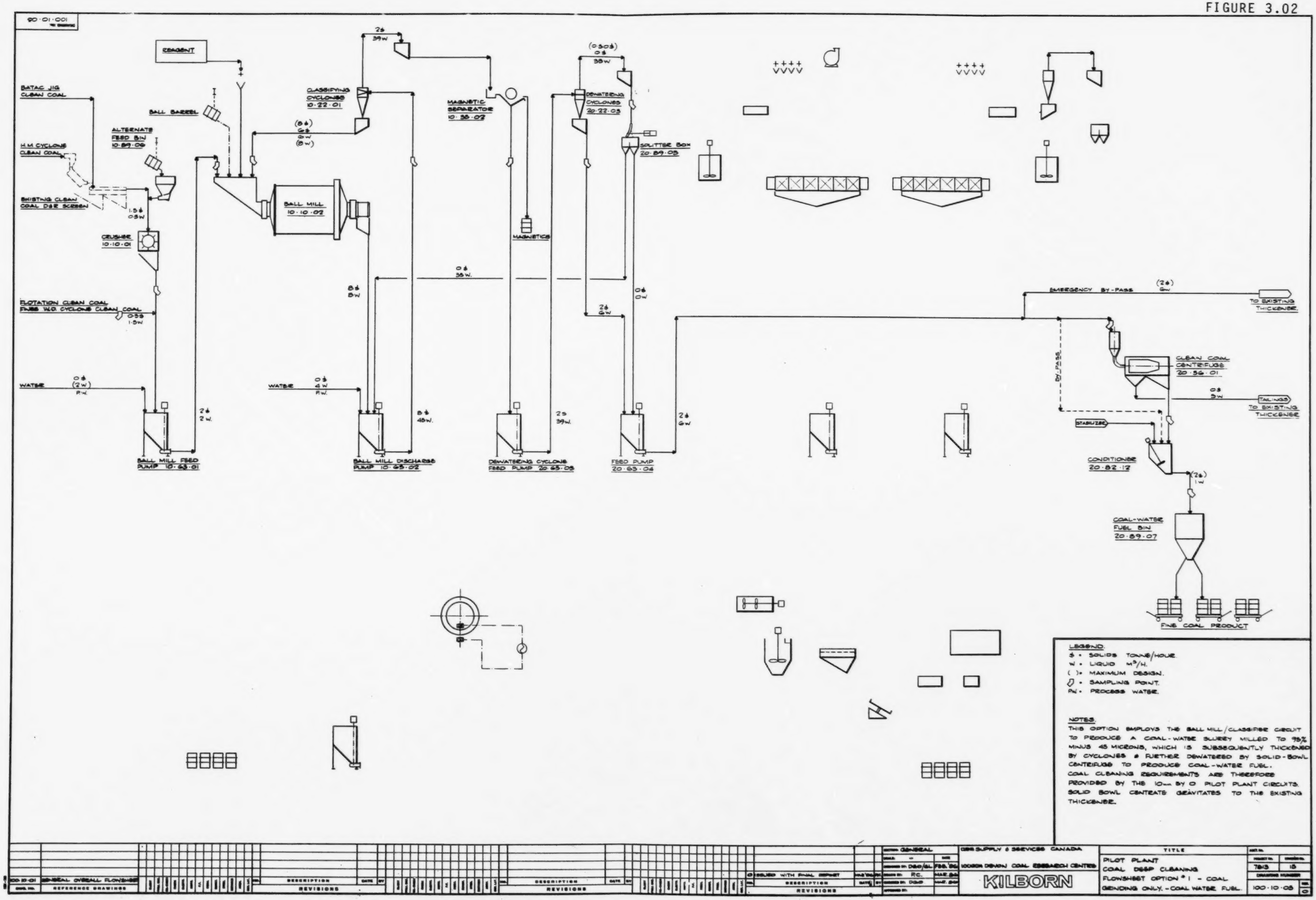
DSS SUPPLY & SERVICES CANADA
LOCATION DEVON COAL RESEARCH CENTRE

KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
GEN. ARR'G'T. - SECTIONS

7815 | 18
DRAWING NUMBER 100-10-04 D

FIGURE 3.02


90·01·001
REAGENT
BATAC JIG CLEAN COAL
H.M. CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
ALTERNATE FEED BIN 10·89·06
BALL BARREL
1.5$ 0.5W
CRUSHER 10·10·01
FLOTATION CLEAN COAL
FINES W.O. CYCLONE CLEAN COAL
0.5$ 1.5W
WATER
0$ (2W) P.W.
BALL MILL FEED PUMP 10·63·01
2$ 2W.
CLASSIFYING CYCLONES 10·22·01
(8$) 6$ 6W (8W)
BALL MILL 10·10·02
2$ 39W
8$ 8W
WATER
0$ 4W P.W.
BALL MILL DISCHARGE PUMP 10·65·02
8$ 45W.
MAGNETIC SEPARATOR 10·38·02
MAGNETICS
0$ 38W.
DEWATERING CYCLONE FEED PUMP 20·65·03
2$ 39W.
(0.30$) 0$ 38W
DEWATERING CYCLONES 20·22·03
SPLITTER BOX 20·89·03
0$ 0W
2$ 6W
FEED PUMP 20·63·04
2$ 6W
EMERGENCY BY-PASS
(2$) 6W
TO EXISTING THICKENER.
BY-PASS
CLEAN COAL CENTRIFUGE 20·56·01
0$ 5W
TAILINGS
TO EXISTING THICKENER
STABILIZER
CONDITIONER 20·82·12
(2$) 1W
COAL-WATER FUEL BIN 20·89·07
FINE COAL PRODUCT

LEGEND.

$ = SOLIDS TONNE/HOUR.
W = LIQUID $M^3$/H.
( ) = MAXIMUM DESIGN.
⌇ = SAMPLING POINT.
P.W. = PROCESS WATER.

NOTES.

THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS SUBSEQUENTLY THICKENED BY CYCLONES & FURTHER DEWATERED BY SOLID-BOWL CENTRIFUGE TO PRODUCE COAL-WATER FUEL.
COAL CLEANING REQUIREMENTS ARE THEREFORE PROVIDED BY THE 10mm BY 0 PILOT PLANT CIRCUITS. SOLID BOWL CENTRATE GRAVITATES TO THE EXISTING THICKENER.

100·10·01 GENERAL OVERALL FLOWSHEET
DWG. NO. REFERENCE DRAWINGS

0 ISSUED WITH FINAL REPORT MAR.'86
DESCRIPTION DATE BY
REVISIONS

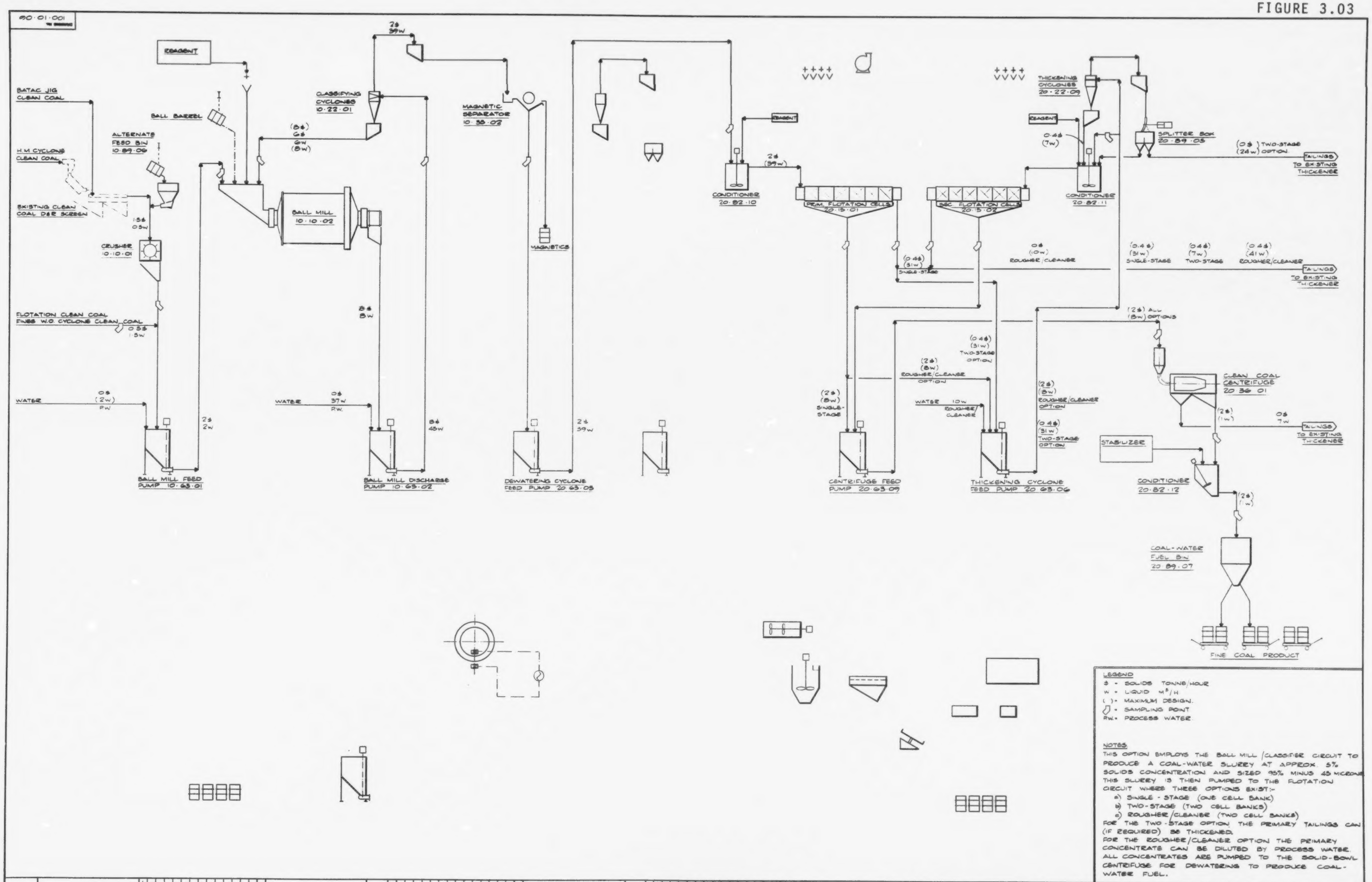
SECTION GENERAL
SCALE —
DESIGNED BY DGO/GL FEB.'86
DRAWN BY RC. MAR.'86
CHECKED BY DGO MAR.'86
APPROVED BY

DSS SUPPLY & SERVICES CANADA
LOCATION DEVON COAL RESEARCH CENTRE
KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION # 1 – COAL GRINDING ONLY. – COAL WATER FUEL.

PROJECT No. 7813
DRAWING No. 15
DRAWING NUMBER 100·10·03
REV. 0

FIGURE 3.03


90·01·001
REAGENT
BATAC JIG
CLEAN COAL
BALL BARREL
H.M. CYCLONE
CLEAN COAL
ALTERNATE
FEED BIN
10·89·06
EXISTING CLEAN
COAL D&R SCREEN
1.5$
0.5W
CRUSHER
10·10·01
FLOTATION CLEAN COAL
FINES W.O. CYCLONE CLEAN COAL
0.5$
1.5W
WATER
0$
(2W)
P.W.
2$
2W
BALL MILL FEED
PUMP 10·63·01
BALL MILL
10·10·02
2$
39W
CLASSIFYING
CYCLONES
10·22·01
(8$)
6$
6W
(8W)
8$
8W
WATER
0$
37W
P.W.
8$
45W
BALL MILL DISCHARGE
PUMP 10·63·02
MAGNETIC
SEPARATOR
10·38·02
MAGNETICS
2$
39W
DEWATERING CYCLONE
FEED PUMP 20·63·05
REAGENT
CONDITIONER
20·82·10
2$
(39W)
PRIM. FLOTATION CELLS
20·15·01
SEC. FLOTATION CELLS
20·15·02
THICKENING
CYCLONES
20·22·09
REAGENT
0.4$
(7W)
CONDITIONER
20·82·11
SPLITTER BOX
20·89·03
(0$) TWO-STAGE
(24W) OPTION
TAILINGS
TO EXISTING
THICKENER
(0.4$)
(31W)
SINGLE-STAGE
0$
(10W)
ROUGHER/CLEANER
(0.4$)
(31W)
SINGLE-STAGE
(0.4$)
(7W)
TWO-STAGE
(0.4$)
(41W)
ROUGHER/CLEANER
TAILINGS
TO EXISTING
THICKENER
(2$) ALL
(8W) OPTIONS
(0.4$)
(31W)
TWO-STAGE
OPTION
(2$)
(8W)
ROUGHER/CLEANER
OPTION
(2$)
(8W)
SINGLE-
STAGE
WATER 10W
ROUGHER/
CLEANER
(2$)
(8W)
ROUGHER/CLEANER
OPTION
(0.4$)
(31W)
TWO-STAGE
OPTION
CENTRIFUGE FEED
PUMP 20·63·09
THICKENING CYCLONE
FEED PUMP 20·63·06
CLEAN COAL
CENTRIFUGE
20·36·01
(2$)
(1W)
0$
7W
TAILINGS
TO EXISTING
THICKENER
STABILIZER
CONDITIONER
20·82·12
(2$)
(1W)
COAL-WATER
FUEL BIN
20·89·07
FINE COAL PRODUCT

LEGEND

$ - SOLIDS TONNE/HOUR
W - LIQUID M³/H
( ) - MAXIMUM DESIGN.
⌐ - SAMPLING POINT
P.W. - PROCESS WATER.

NOTES.

THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY AT APPROX. 5% SOLIDS CONCENTRATION AND SIZED 95% MINUS 45 MICRONS. THIS SLURRY IS THEN PUMPED TO THE FLOTATION CIRCUIT WHERE THREE OPTIONS EXIST:-

a) SINGLE-STAGE (ONE CELL BANK)
b) TWO-STAGE (TWO CELL BANKS)
c) ROUGHER/CLEANER (TWO CELL BANKS)

FOR THE TWO-STAGE OPTION THE PRIMARY TAILINGS CAN (IF REQUIRED) BE THICKENED.
FOR THE ROUGHER/CLEANER OPTION THE PRIMARY CONCENTRATE CAN BE DILUTED BY PROCESS WATER.
ALL CONCENTRATES ARE PUMPED TO THE SOLID-BOWL CENTRIFUGE FOR DEWATERING TO PRODUCE COAL-WATER FUEL.

| | | |
|---|---|---|
| 100·10·01 | GENERAL OVERALL FLOWSHEET | |
| DWG. No. | REFERENCE DRAWINGS | |

| No. | DESCRIPTION | DATE | BY |
|---|---|---|---|
| 0 | ISSUED WITH FINAL REPORT | MAR.'86 | P.C. |

REVISIONS

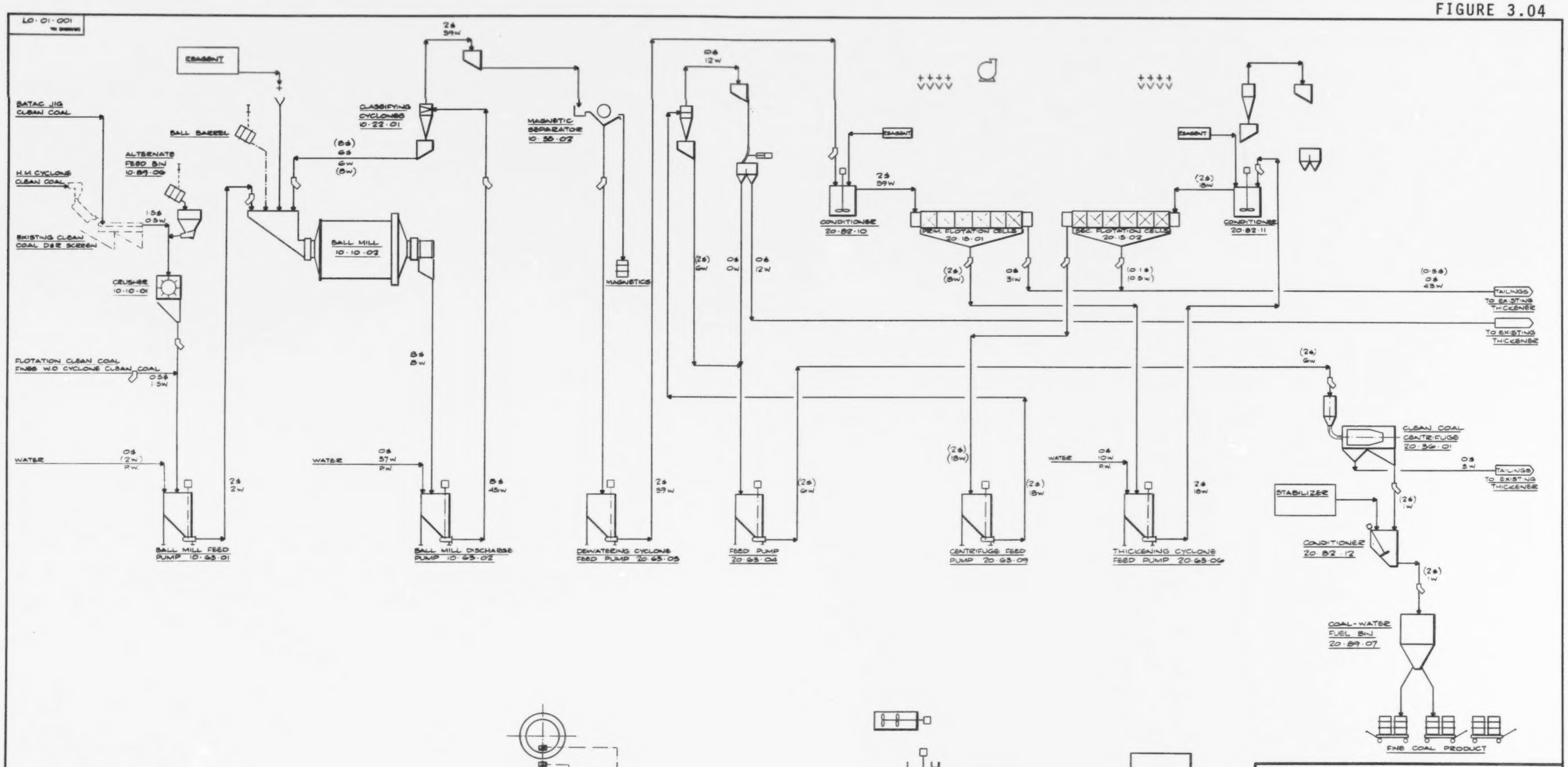
SECTION: GENERAL
SCALE: —
DESIGNED BY: D.G.O./G.L. FEB.'86
DRAWN BY: P.C. MAR.'86
CHECKED BY: D.G.O. MAR.'86
APPROVED BY:

CBG SUPPLY & SERVICES CANADA
LOCATION DEVON COAL RESEARCH CENTRE
KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #2 - TWO STAGE
FLOTATION - COAL-WATER FUEL

PROJECT No. 7813
DIVISION No. 13
DRAWING NUMBER 100·10·06
REV. 0

FIGURE 3.04


LO·01·001
BATAC JIG CLEAN COAL
H.M. CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
ALTERNATE FEED BIN 10·89·06
1·5$ 0·5W
CRUSHER 10·10·01
REAGENT
BALL BARREL
FLOTATION CLEAN COAL FINES W.O CYCLONE CLEAN COAL
0·5$ 1·5W
WATER
0$ (2W) P.W.
BALL MILL FEED PUMP 10·63·01
2$ 2W
(8$) 6$ 6W (8W)
BALL MILL 10·10·02
CLASSIFYING CYCLONES 10·22·01
2$ 39W
8$ 8W
WATER
0$ 57W P.W
BALL MILL DISCHARGE PUMP 10·63·02
8$ 45W
MAGNETIC SEPARATOR 10·55·02
MAGNETICS
DEWATERING CYCLONE FEED PUMP 20·63·05
2$ 39W
10$ 12W
(2$) 6W
0$ 0W
0$ 12W
FEED PUMP 20·63·04
(2$) 6W
REAGENT
2$ 39W
CONDITIONER 20·82·10
PRIM. FLOTATION CELLS 20·15·01
(2$) (8W)
0$ 31W
SEC. FLOTATION CELLS 20·15·02
(0·1$) (0·5W)
REAGENT
(2$) 8W
CONDITIONER 20·82·11
(0·5$) 0$ 43W
TAILINGS
TO EXISTING THICKENER
TO EXISTING THICKENER
(2$) (18W)
(2$) 18W
CENTRIFUGE FEED PUMP 20·63·09
WATER
0$ 10W P.W.
2$ 18W
THICKENING CYCLONE FEED PUMP 20·63·06
(2$) 6W
CLEAN COAL CENTRIFUGE 20·36·01
0$ 5W
TAILINGS
TO EXISTING THICKENER
STABILIZER
(2$) 1W
CONDITIONER 20·82·12
(2$) 1W
COAL-WATER FUEL BIN 20·89·07
FINE COAL PRODUCT

LEGEND

$ - SOLIDS TONNE/HOUR.
W - LIQUID M³/H.
( )- MAXIMUM DESIGN.
⌐ - SAMPLING POINT.
PW- PROCESS WATER.

NOTES:

THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS SUBSEQUENTLY PUMPED TO THE PRIMARY FLOTATION CELLS FOR SINGLE-STAGE FLOTATION TO PRODUCE A CLEAN COAL CONCENTRATE. THE FROTH CONCENTRATE IS THEN PUMPED TO THE CONDITIONING TANK OF THE SECONDARY FLOTATION CELLS AFTER DILUTION IF REQUIRED. COAL DEPRESSION REAGENT IS ADDED WITH A PYRITE COLLECTOR AND A PYRITE CONCENTRATE IS OBTAINED BY SUBSEQUENT FLOTATION. THE COAL PRODUCT IS THEN PUMPED TO THE THICKENING CYCLONES AND FINALLY DEWATERED BY THE SOLID-BOWL CENTRIFUGE TO OBTAIN COAL-WATER FUEL.

| DWG. NO. | REFERENCE DRAWINGS |
|---|---|
| 100·10·01 | GENERAL OVERALL FLOWSHEET |

| NO. | DESCRIPTION | DATE | BY |
|---|---|---|---|
| 0 | ISSUED WITH FINAL REPORT | MAR '86 | P.C. |

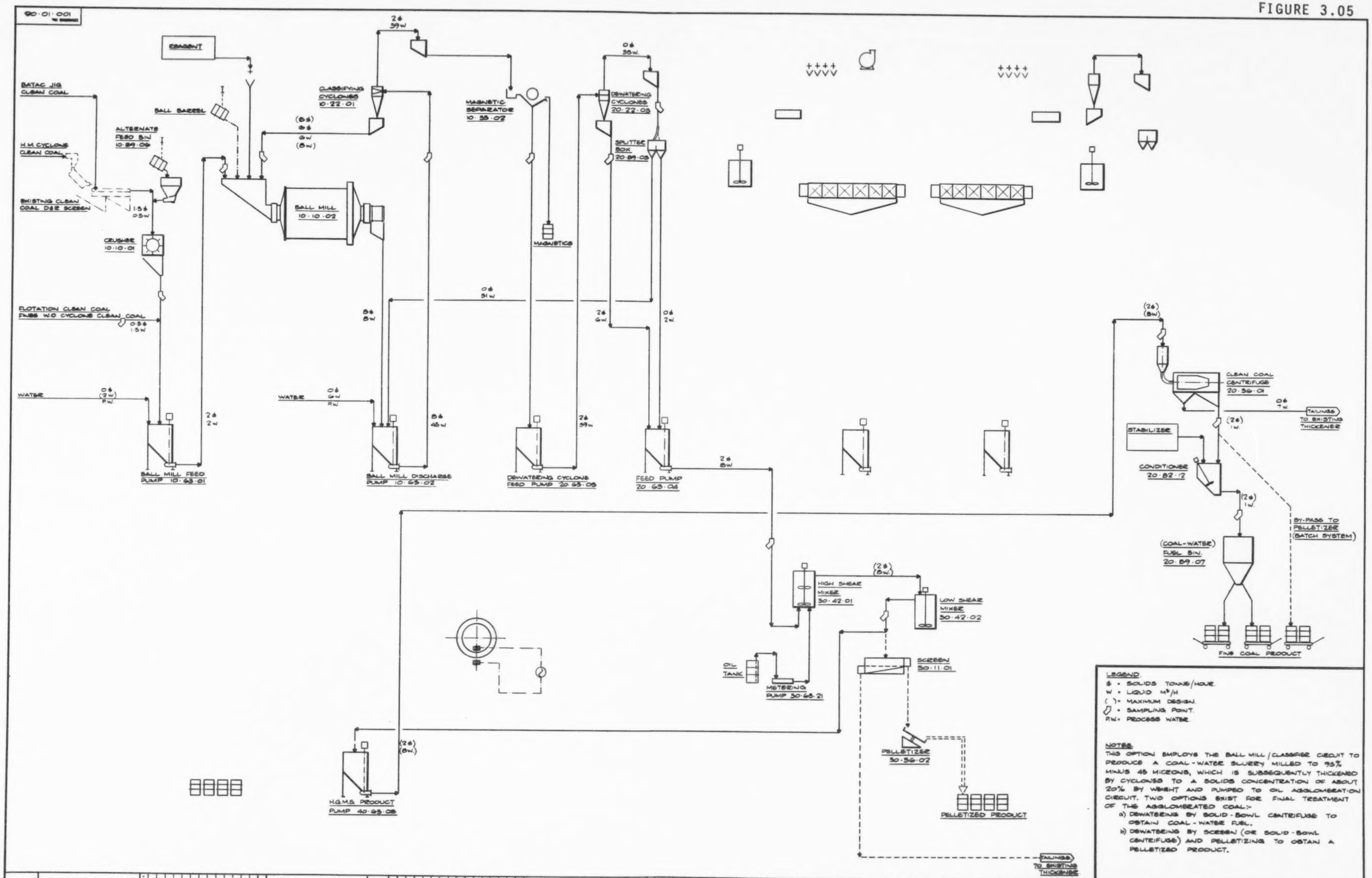
SECTION: GENERAL
SCALE: —
DESIGNED BY: DGO/GL FEB. '86
DRAWN BY: P.C. MAR. '86
CHECKED BY: DGO MAR. '86
APPROVED BY:

DSS SUPPLY & SERVICES CANADA
LOCATION DEVON COAL RESEARCH CENTRE
KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #3 - REVERSE
FLOTATION - COAL WATER FUEL

PROJECT NO. 7813
DIVISION NO. 15
DRAWING NUMBER 100·10·07
REV. 0

FIGURE 3.05


90·01·001
REAGENT
BATAC JIG CLEAN COAL
BALL BARREL
ALTERNATE FEED BIN 10·89·06
H.M. CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
1.5$ 0.5W
CRUSHER 10·10·01
FLOTATION CLEAN COAL FINES W.O CYCLONE CLEAN COAL
0.5$ 1.5W
WATER
0$ (2W) P.W.
2$ 2W
BALL MILL FEED PUMP 10·65·01
(8$) 6$ 6W (8W)
BALL MILL 10·10·02
2$ 39W
CLASSIFYING CYCLONES 10·22·01
8$ 8W
0$ 31W
WATER
0$ 6W P.W.
8$ 45W
BALL MILL DISCHARGE PUMP 10·65·02
MAGNETIC SEPARATOR 10·35·02
MAGNETICS
2$ 39W
DEWATERING CYCLONE FEED PUMP 20·65·05
0$ 35W.
DEWATERING CYCLONES 20·22·03
SPLITTER BOX 20·89·08
2$ 6W.
0$ 2W.
FEED PUMP 20·65·04
2$ 8W
(2$) (8W)
CLEAN COAL CENTRIFUGE 20·36·01
0$ 7W.
TAILINGS TO EXISTING THICKENER
STABILIZER
(2$) 1W.
CONDITIONER 20·82·12
(2$) 1W.
BY-PASS TO PELLETIZER (BATCH SYSTEM)
(COAL-WATER) FUEL BIN. 20·89·07
FINE COAL PRODUCT
(2$) (8W.)
HIGH SHEAR MIXER 30·42·01
LOW SHEAR MIXER 30·42·02
OIL TANK
METERING PUMP 30·65·21
SCREEN 30·11·01
PELLETIZER 30·56·02
PELLETIZED PRODUCT
TAILINGS TO EXISTING THICKENER
(2$) (8W.)
H.G.M.S. PRODUCT PUMP 40·65·08

LEGEND.

$ - SOLIDS TONNE/HOUR.

W - LIQUID M³/H

( ) - MAXIMUM DESIGN.

⌂ - SAMPLING POINT.

P.W. - PROCESS WATER.

NOTES.

THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS SUBSEQUENTLY THICKENED BY CYCLONES TO A SOLIDS CONCENTRATION OF ABOUT 20% BY WEIGHT AND PUMPED TO OIL AGGLOMERATION CIRCUIT. TWO OPTIONS EXIST FOR FINAL TREATMENT OF THE AGGLOMERATED COAL:-

a) DEWATERING BY SOLID-BOWL CENTRIFUGE TO OBTAIN COAL-WATER FUEL.

b) DEWATERING BY SCREEN (OR SOLID-BOWL CENTRIFUGE) AND PELLETIZING TO OBTAIN A PELLETIZED PRODUCT.

| | |
|---|---|
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KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #4
OIL AGGLOMERATION.

PROJECT No. 7813
DIVISION No. 18
DRAWING NUMBER 100·10·08
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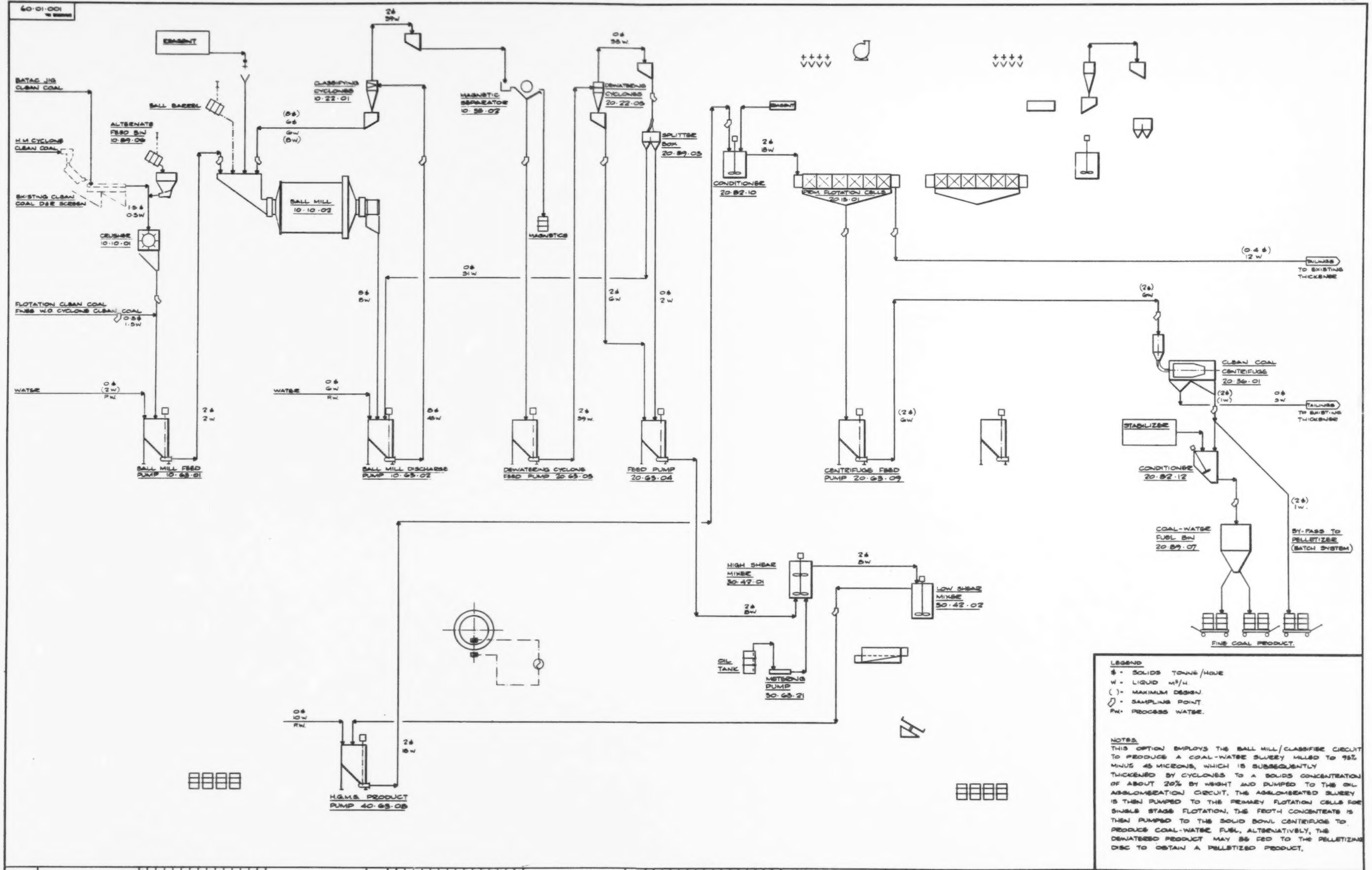
FIGURE 3.06


60·01·001
REAGENT
BATAC JIG CLEAN COAL
H.M CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
1.5 \$ 0.5W
ALTERNATE FEED BIN 10·89·06
BALL BARREL
CRUSHER 10·10·01
FLOTATION CLEAN COAL FINES W.O CYCLONE CLEAN COAL
0.8 \$ 1.5W
WATER
0 \$ (2W) PW.
BALL MILL FEED PUMP 10·63·01
2 \$ 2 W
CLASSIFYING CYCLONES 10·22·01
2 \$ 39W
(8 \$) 6 \$ 6W (8W)
BALL MILL 10·10·02
8 \$ 8W
0 \$ 31 W
WATER
0 \$ 6W PW.
BALL MILL DISCHARGE PUMP 10·63·02
8 \$ 45W
MAGNETIC SEPARATOR 10·38·02
MAGNETICS
DEWATERING CYCLONE FEED PUMP 20·63·05
2 \$ 39 W.
DEWATERING CYCLONES 20·22·06
0 \$ 38 W.
SPLITTER BOX 20·89·03
2 \$ 6W
0 \$ 2 W
FEED PUMP 20·63·04
REAGENT
CONDITIONER 20·82·10
2 \$ 8W
PRIM. FLOTATION CELLS 20·13·01
(0.4 \$) 12 W
TAILINGS TO EXISTING THICKENER
CENTRIFUGE FEED PUMP 20·63·09
(2 \$) 6W
CLEAN COAL CENTRIFUGE 20·36·01
(2 \$) (1W)
0 \$ 3W
TAILINGS TO EXISTING THICKENER
STABILIZER
CONDITIONER 20·82·12
(2 \$) 1W.
COAL-WATER FUEL BIN 20·89·07
BY-PASS TO PELLETIZER (BATCH SYSTEM)
FINE COAL PRODUCT.
HIGH SHEAR MIXER 30·47·01
2 \$ 8W
LOW SHEAR MIXER 30·42·02
OIL TANK
METERING PUMP 30·63·21
0 \$ 10W PW.
2 \$ 18 W
H.G.M.S. PRODUCT PUMP 40·63·08

LEGEND
\$ - SOLIDS TONNE/HOUR
W - LIQUID $m^3/H$
( ) - MAXIMUM DESIGN.
▱ - SAMPLING POINT.
PW - PROCESS WATER.

NOTES.
THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS SUBSEQUENTLY THICKENED BY CYCLONES TO A SOLIDS CONCENTRATION OF ABOUT 20% BY WEIGHT AND PUMPED TO THE OIL AGGLOMERATION CIRCUIT. THE AGGLOMERATED SLURRY IS THEN PUMPED TO THE PRIMARY FLOTATION CELLS FOR SINGLE STAGE FLOTATION. THE FROTH CONCENTRATE IS THEN PUMPED TO THE SOLID BOWL CENTRIFUGE TO PRODUCE COAL-WATER FUEL. ALTERNATIVELY, THE DEWATERED PRODUCT MAY BE FED TO THE PELLETIZING DISC TO OBTAIN A PELLETIZED PRODUCT.

| | |
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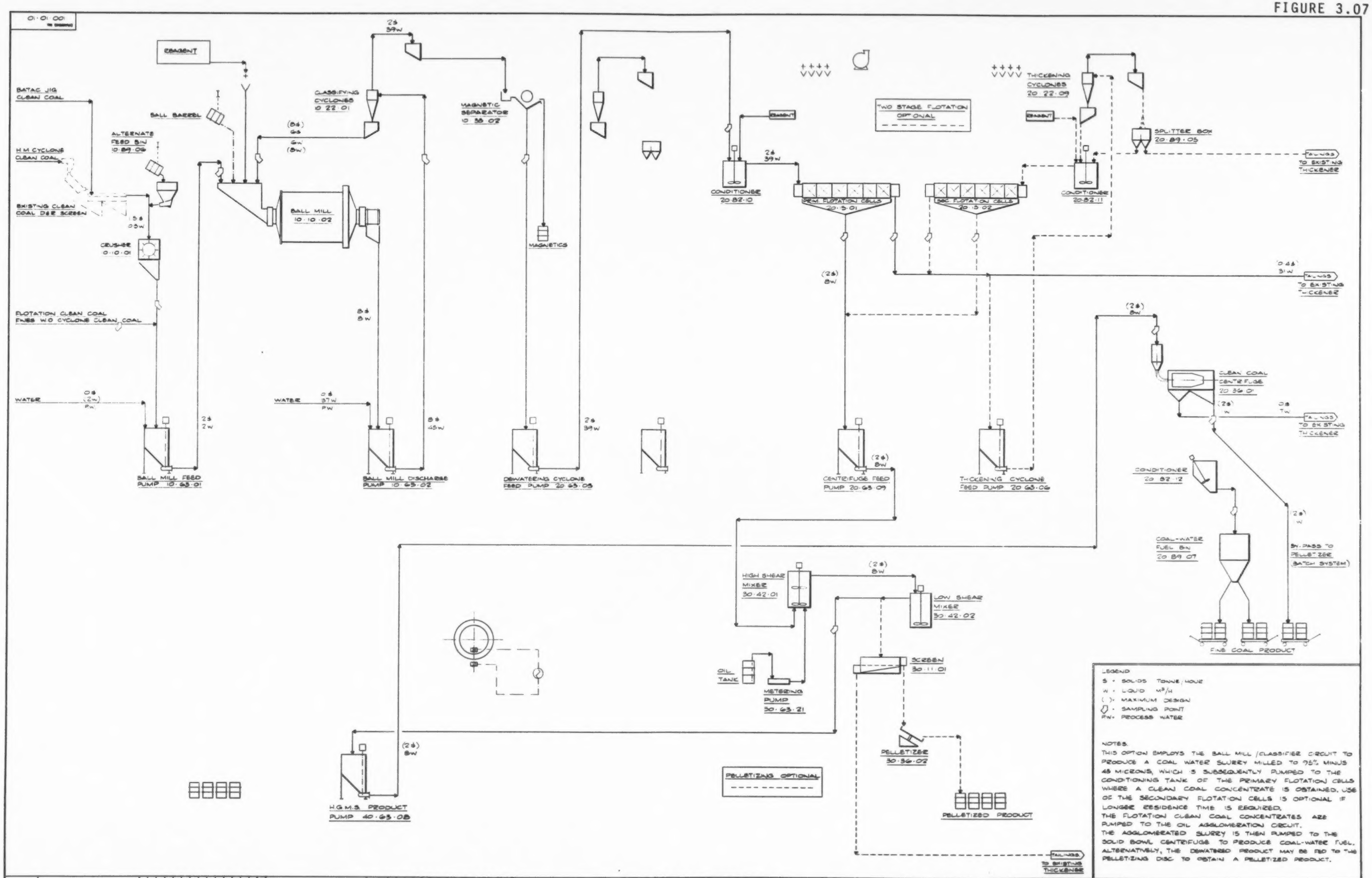
DSS SUPPLY & SERVICES CANADA
DEVON COAL RESEARCH CENTRE
KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #3 - OIL AGGLOMERATION WITH SINGLE STAGE FLOTATION

7813 15
100·10·09 0

FIGURE 3.07


01·01·001
REAGENT
BATAC JIG CLEAN COAL
BALL BARREL
ALTERNATE FEED BIN 10·89·06
H.M CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
1.5$ 0.5W
CRUSHER 0·10·01
FLOTATION CLEAN COAL FINES W.O CYCLONE CLEAN COAL
WATER
0$ (2W) PW
2$ 2W
BALL MILL FEED PUMP 10·63·01
CLASSIFYING CYCLONES 10 22 01
2$ 39W
(8$) 6$ 6W (8W)
BALL MILL 10·10·02
8$ 8W
WATER
0$ 37W PW
8$ 45W
BALL MILL DISCHARGE PUMP 10·63·02
MAGNETIC SEPARATOR 10 38 02
MAGNETICS
2$ 39W
DEWATERING CYCLONE FEED PUMP 20 63·05
REAGENT
CONDITIONER 20·82·10
2$ 39W
PRIM. FLOTATION CELLS 20·15·01
TWO STAGE FLOTATION OPTIONAL
SEC. FLOTATION CELLS 20·15·02
THICKENING CYCLONES 20 22·09
REAGENT
SPLITTER BOX 20·89·05
CONDITIONER 20·82·11
TAILINGS TO EXISTING THICKENER
(0.4$) 31W
TAILINGS TO EXISTING THICKENER
(2$) 8W
CENTRIFUGE FEED PUMP 20·63·09
(2$) 8W
THICKENING CYCLONE FEED PUMP 20 63·06
(2$) 8W
CLEAN COAL CENTRIFUGE 20 36·01
(2$) W
0$ 7W
TAILINGS TO EXISTING THICKENER
CONDITIONER 20 82 ·12
(2$) W
COAL-WATER FUEL BIN 20 89 07
BY-PASS TO PELLETIZER (BATCH SYSTEM)
FINE COAL PRODUCT
HIGH SHEAR MIXER 30·42·01
(2$) 8W
LOW SHEAR MIXER 30·42·02
OIL TANK
METERING PUMP 30·63·21
SCREEN 30·11·01
PELLETIZER 30·36·02
PELLETIZED PRODUCT
PELLETIZING OPTIONAL
(2$) 8W
H.G.M.S. PRODUCT PUMP 40·63·08
TAILINGS TO EXISTING THICKENER

LEGEND

$ · SOLIDS TONNE/HOUR
W · LIQUID $M^3/H$
( )· MAXIMUM DESIGN
◊ · SAMPLING POINT
PW· PROCESS WATER

NOTES.

THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS SUBSEQUENTLY PUMPED TO THE CONDITIONING TANK OF THE PRIMARY FLOTATION CELLS WHERE A CLEAN COAL CONCENTRATE IS OBTAINED. USE OF THE SECONDARY FLOTATION CELLS IS OPTIONAL IF LONGER RESIDENCE TIME IS REQUIRED.
THE FLOTATION CLEAN COAL CONCENTRATES ARE PUMPED TO THE OIL AGGLOMERATION CIRCUIT.
THE AGGLOMERATED SLURRY IS THEN PUMPED TO THE SOLID BOWL CENTRIFUGE TO PRODUCE COAL-WATER FUEL. ALTERNATIVELY, THE DEWATERED PRODUCT MAY BE FED TO THE PELLETIZING DISC TO OBTAIN A PELLETIZED PRODUCT.

| | |
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KILBORN

TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION "G - SINGLE STAGE
FLOTATION WITH OIL AGGLOMERATION

PROJECT NO. 7813
DIVISION NO. 15
DRAWING NUMBER 100·10·10
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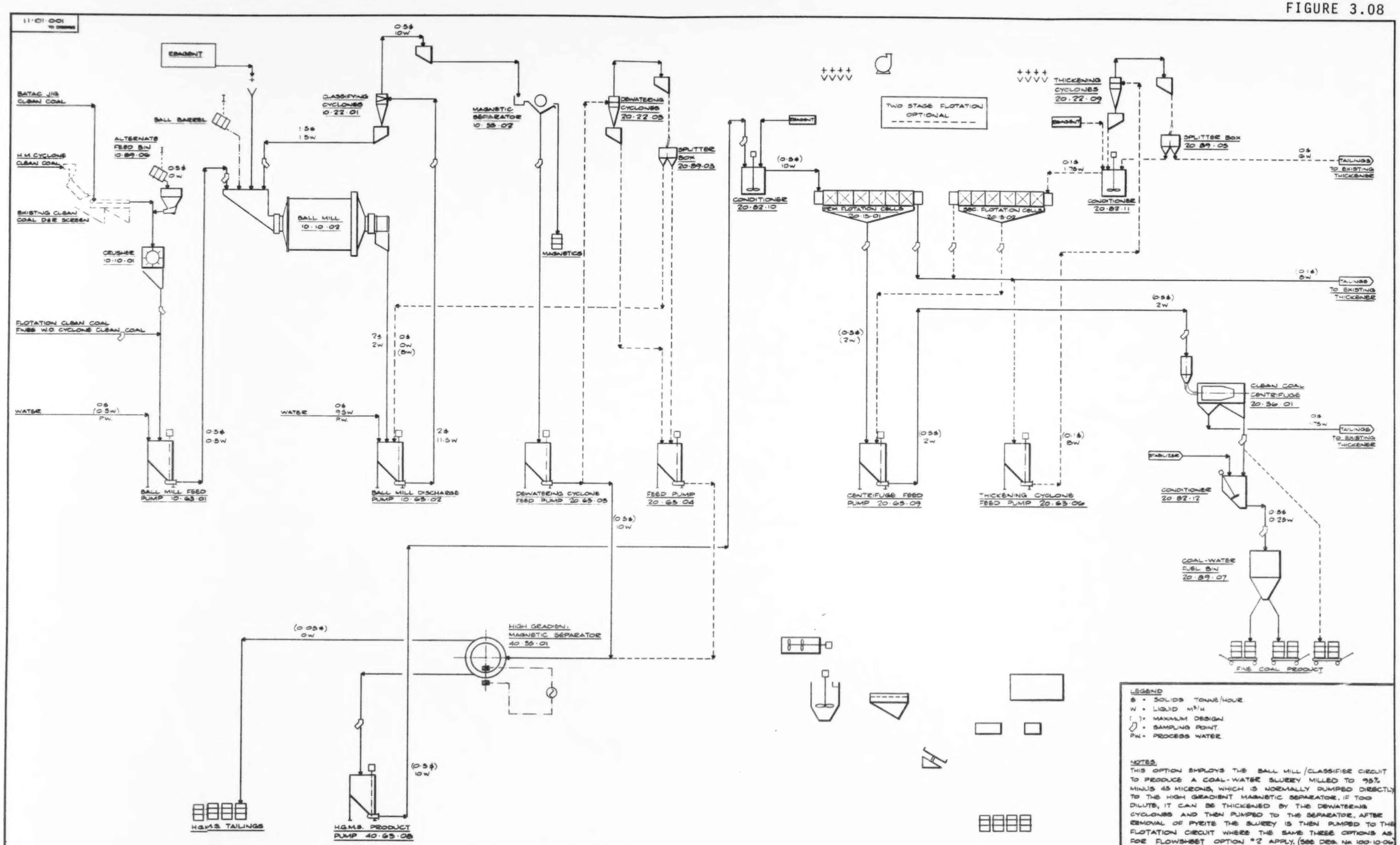
FIGURE 3.08


11·01·001
REAGENT
BATAC JIG CLEAN COAL
BALL BARREL
ALTERNATE FEED BIN 10·89·06
H.M. CYCLONE CLEAN COAL
0.5$ 0W
EXISTING CLEAN COAL D&R SCREEN
CRUSHER 10·10·01
FLOTATION CLEAN COAL FINES W.O. CYCLONE CLEAN COAL
WATER
0$ (0.5W) P.W.
BALL MILL FEED PUMP 10·63·01
0.5$ 0.5W
1.5$ 1.5W
BALL MILL 10·10·02
CLASSIFYING CYCLONES 10·22·01
0.5$ 10W
2$ 2W
0$ 0W (8W)
WATER
0$ 9.5W P.W.
2$ 11.5W
BALL MILL DISCHARGE PUMP 10·63·02
MAGNETIC SEPARATOR 10·55·02
MAGNETICS
DEWATERING CYCLONES 20·22·03
SPLITTER BOX 20·89·03
DEWATERING CYCLONE FEED PUMP 20·63·03
FEED PUMP 20·63·04
(0.5$) 10W
HIGH GRADIENT MAGNETIC SEPARATOR 40·55·01
(0.05$) 0W
H.G.M.S. TAILINGS
(0.5$) 10W
H.G.M.S. PRODUCT PUMP 40·63·08
REAGENT
CONDITIONER 20·82·10
(0.5$) 10W
PRIM. FLOTATION CELLS 20·15·01
TWO STAGE FLOTATION OPTIONAL
SEC. FLOTATION CELLS 20·15·02
THICKENING CYCLONES 20·22·09
REAGENT
0.1$ 1.75W
CONDITIONER 20·82·11
SPLITTER BOX 20·89·05
0$ 8W
TAILINGS TO EXISTING THICKENER
(0.1$) 8W
TAILINGS TO EXISTING THICKENER
(0.5$) 2W
(0.5$) (2W)
(0.5$) 2W
CENTRIFUGE FEED PUMP 20·63·09
(0.1$) 8W
THICKENING CYCLONE FEED PUMP 20·63·06
CLEAN COAL CENTRIFUGE 20·36·01
0$ 1.75W
TAILINGS TO EXISTING THICKENER
STABILIZER
CONDITIONER 20·82·12
0.5$ 0.25W
COAL-WATER FUEL BIN 20·89·07
FINE COAL PRODUCT

LEGEND
$ - SOLIDS TONNE/HOUR
W - LIQUID M³/H
( ) - MAXIMUM DESIGN
⌀ - SAMPLING POINT.
PW - PROCESS WATER

NOTES.
THIS OPTION EMPLOYS THE BALL MILL/CLASSIFIER CIRCUIT TO PRODUCE A COAL-WATER SLURRY MILLED TO 95% MINUS 45 MICRONS, WHICH IS NORMALLY PUMPED DIRECTLY TO THE HIGH GRADIENT MAGNETIC SEPARATOR. IF TOO DILUTE, IT CAN BE THICKENED BY THE DEWATERING CYCLONES AND THEN PUMPED TO THE SEPARATOR. AFTER REMOVAL OF PYRITE THE SLURRY IS THEN PUMPED TO THE FLOTATION CIRCUIT WHERE THE SAME THREE OPTIONS AS FOR FLOWSHEET OPTION #2 APPLY. (SEE DRG. No. 100·10·06) THE FLOTATION CLEAN COAL CONCENTRATE IS PUMPED TO THE SOLID-BOWL CENTRIFUGE TO PRODUCE COAL-WATER FUEL.

| | |
|---|---|
| 100·10·01 | GENERAL OVERALL FLOWSHEET. |
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TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #7 - H.G.M.S. CLEANING
WITH TWO STAGE FLOTATION

PROJECT No. 7813
DRAWING No. 100·10·11
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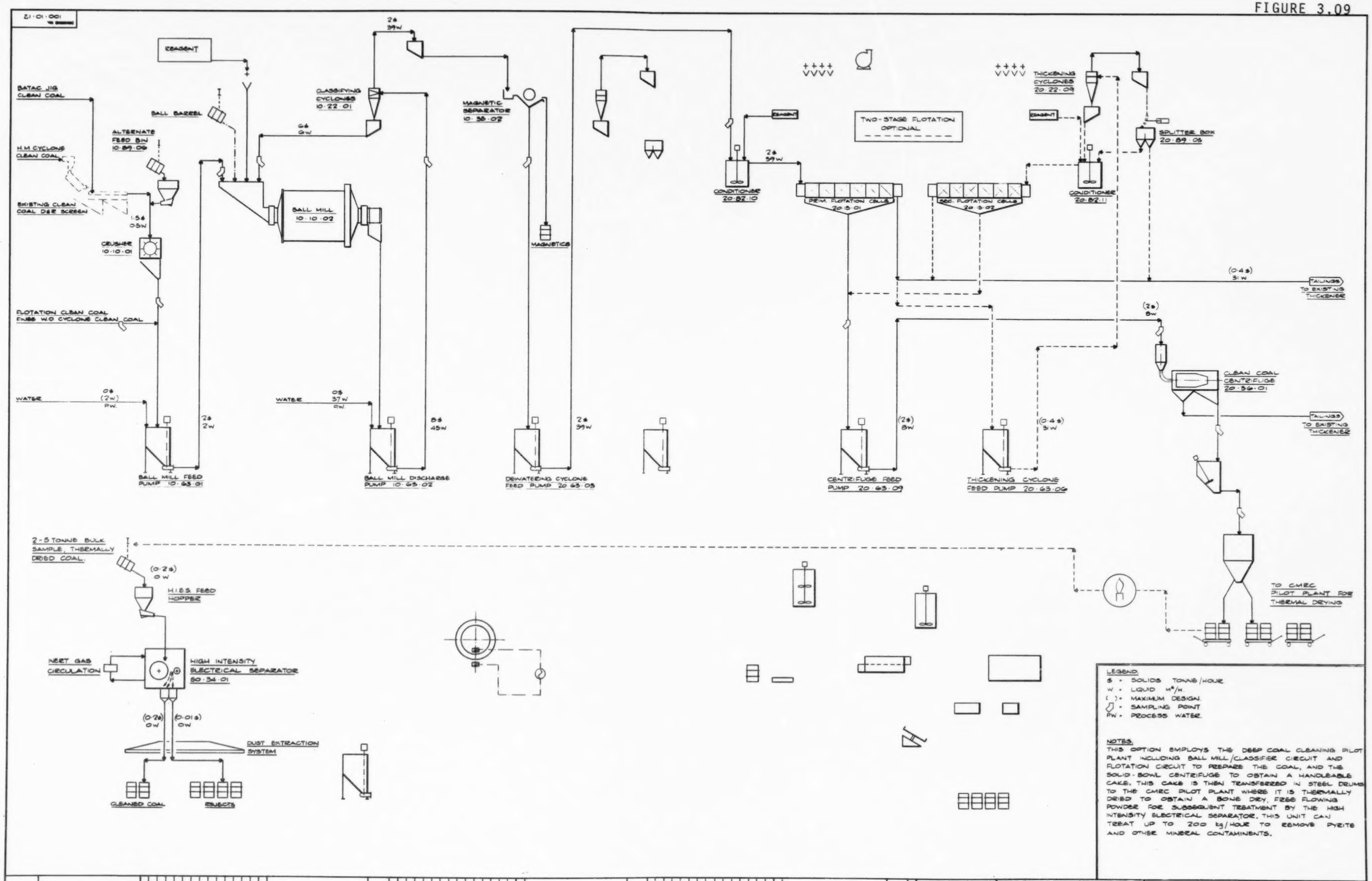
FIGURE 3.09


21·01·001
REAGENT
BATAC JIG CLEAN COAL
BALL BARREL
ALTERNATE FEED BIN 10·89·06
H.M CYCLONE CLEAN COAL
EXISTING CLEAN COAL D&R SCREEN
1.5s 0.5w
CRUSHER 10·10·01
CLASSIFYING CYCLONES 10·22·01
2s 39w
6s 6w
BALL MILL 10·10·02
MAGNETIC SEPARATOR 10·38·02
MAGNETICS
FLOTATION CLEAN COAL
FINES W.O CYCLONE CLEAN COAL
WATER
0s (2w) PW.
2s 2w
BALL MILL FEED PUMP 10·63·01
WATER
0s 37w 0w.
8s 45w
BALL MILL DISCHARGE PUMP 10·63·02
2s 39w
DEWATERING CYCLONE FEED PUMP 20·63·05
REAGENT
CONDITIONER 20·82·10
2s 39w
PRIM. FLOTATION CELLS 20·15·01
TWO-STAGE FLOTATION OPTIONAL
SEC. FLOTATION CELLS 20·15·02
THICKENING CYCLONES 20·22·09
REAGENT
CONDITIONER 20·82·11
SPLITTER BOX 20·89·05
(0·4s) 31w
TAILINGS
TO EXISTING THICKENER
(2s) 8w
CLEAN COAL CENTRIFUGE 20·36·01
TAILINGS
TO EXISTING THICKENER
(2s) 8w
CENTRIFUGE FEED PUMP 20·63·09
(0·4s) 31w
THICKENING CYCLONE FEED PUMP 20·63·06
2-5 TONNE BULK SAMPLE, THERMALLY DRIED COAL.
(0·2s) 0w
H.I.E.S. FEED HOPPER
INERT GAS CIRCULATION
HIGH INTENSITY ELECTRICAL SEPARATOR 50·34·01
(0·2s) 0w
(0·01s) 0w
DUST EXTRACTION SYSTEM
CLEANED COAL
REJECTS
TO CMRC PILOT PLANT FOR THERMAL DRYING

LEGEND.
s = SOLIDS TONNE/HOUR.
W = LIQUID $M^3/H$.
( ) = MAXIMUM DESIGN.
⌂ = SAMPLING POINT
PW = PROCESS WATER.

NOTES.
THIS OPTION EMPLOYS THE DEEP COAL CLEANING PILOT PLANT INCLUDING BALL MILL/CLASSIFIER CIRCUIT AND FLOTATION CIRCUIT TO PREPARE THE COAL, AND THE SOLID-BOWL CENTRIFUGE TO OBTAIN A HANDLEABLE CAKE. THIS CAKE IS THEN TRANSFERRED IN STEEL DRUMS TO THE CMRC PILOT PLANT WHERE IT IS THERMALLY DRIED TO OBTAIN A BONE DRY, FREE FLOWING POWDER FOR SUBSEQUENT TREATMENT BY THE HIGH INTENSITY ELECTRICAL SEPARATOR. THIS UNIT CAN TREAT UP TO 200 kg/HOUR TO REMOVE PYRITE AND OTHER MINERAL CONTAMINENTS.

| | | | | |
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TITLE
PILOT PLANT
COAL DEEP CLEANING
FLOWSHEET OPTION #8 - HIGH INTENSITY
ELECTRICAL SEPARATION OF DRY, CLEAN COAL

PROJECT NO. 7815
DRAWING NO. 13
DRAWING NUMBER 100·10·12
REV. 0

# 4.0 EQUIPMENT SPECIFICATIONS

# 4.0 EQUIPMENT SPECIFICATIONS

## 4.1 GENERAL

All equipment items required for the Deep Coal Cleaning Pilot Plant are given in the Equipment Ledger included as Appendix 'B'.

During the initial stage of flowsheet design, Kilborn prepared Preliminary Equipment Specifications for each of the major items of equipment. These documents were then sent to potential suppliers together with a request for a budget price and descriptive details of any unit offered. The preliminary quotations received were used to prepare a preliminary cost estimate for the Scientific Authority, which was used for budgetary purposes. Detailed performance requirements were later prepared for all other items of equipment as described in the Equipment Ledger in Appendix 'B'.

## 4.2 MAJOR EQUIPMENT

With reference to the General Flowsheet included as Figure 3.01 in the preceding Section 3.3, Performance Specifications have been prepared by Kilborn for the following major items of equipment:

| Performance Spec. No. | Subject | Date of Issue Preliminary | Date of Issue Revision |
|---|---|---|---|
| 7813-15-01 | Ball Mill | 29.11.85 | 17.03.86 |
| 7813-15-02 | Clean Coal Crusher | 9.12.85 | 17.03.86 |
| 7813-15-03 | Cyclones | 17.12.85 | 17.03.86 |
| 7813-15-04 | Froth Flotation Cell | 17.12.85 | 17.03.86 |
| 7813-15-05 | Conditioner | 31.12.85 | 17.03.86 |
| 7813-15-06 | Solid Bowl Centrifuge | 31.12.85 | 17.03.86 |

| Performance Spec. No. | Subject | Date of Issue Preliminary | Date of Issue Revision |
|---|---|---|---|
| 7813-15-07 | Slurry Pumps | 02.01.86 | 17.03.86 |
| 7813-15-08 | Wet Magnetic Drum Separator | 02.01.86 | 17.03.86 |

Copies of the revised versions of each of the above Performance Specifications are included in Appendix 'C'.

The HGMS and HIES units are of such a specific nature that only a very limited number of companies manufacture the exact equipment required. In these cases, Kilborn contacted each company directly, providing technical requirements by telex. The required details were then supplied by each prospective vendor and Kilborn proceeded to carry out technical evaluations of each bid received. It is, therefore, proposed that when the Deep Coal Cleaning Project proceeds to the procurement phase, ECRL contacts each of the companies listed below to review any further technical developments and to obtain revised proposals based upon the following operating conditions:

(a) Magnetic Separator

| | | |
|---|---|---|
| Feed to Unit | - | Up to 500 kg per hour |
| Material | - | Milled coal slurry ranging in solids concentration from 10 to 30% by weight |
| Size Distribution | - | 95% passing 45 microns |
| Ferro-magnetics Content* | - | Less than 0.05% by weight |
| Para-magnetics Content** | - | 5% absolute maximum |
| | - | 2% normal maximum |
| Para-magnetics Type | - | Mainly pyrite (iron sulphide) mineral |

* Slurry will be pre-treated by wet drum magnetic unit.

** Magnetic material assumed to have similar size distribution to non-magnetic (coal).

Potential Suppliers

Sala and Boxmag-Rapid (both imported). See Appendix 'D' for further details (U.S.A. and U.K. respectively).

(b) Electrical Separator

Feed to Unit - Up to 500 kg per hour
Material - Milled coal previously thermal dried to below 5% moisture content (free or surface moisture)
Temperature - Ambient
Size Distribution - 95% passing 45 microns
- 85% passing 25 microns
Ferro-magnetics Content - Less than 0.05% by weight
Para-magnetics Content - 5% maximum (mainly pyrite)
Other Liberated Gangue - 5% maximum (mainly silica and alumina)

Potential Supplier

Carpco (imported U.S.A.). See Appendix 'D' for further details.

## 4.3 OTHER EQUIPMENT

All other equipment items, as listed in the Equipment Ledger in Appendix 'B' of the Report, have been adequately specified in terms of operating conditions and general installation requirements. These details were transmitted to at least one potential vendor either by telex or telephone communication. Sufficiently detailed responses were received in all cases to permit confident selection and the determination of a budget price for estimating purposes.

## 4.4 PROCUREMENT CONSIDERATIONS

For the current Project, it has not been possible to obtain fully detailed and certified vendor drawings for any item of equipment selected for inclusion in the plant; because a firm purchase order is required to obtain certified information. Consequently, when the Project proceeds to the construction phase and certified vendor drawings are subsequently obtained from each of the successful bidders, the final detailed engineering design may proceed to completion, and construction drawings can be produced.

Kilborn has selected one particular item of equipment from each set of bid responses, and while it is most likely that the majority of these will eventually prove to be the ones that are purchased, it is also probable that, in certain cases, there will be more favourable bids received from other alternatives.

Kilborn, therefore, recommends that ECRL make provision for future revision of the Kilborn design drawings and also utilize, if possible, the Detailed Equipment Specifications provided in Appendix 'C' during the procurement process. To facilitate the most effective technical adjudication of bids, these Specifications have been revised following their original use in the preliminary enquiry for this Project.

## 4.5 BID EVALUATIONS FOR MECHANICAL EQUIPMENT

Preliminary enquiries for each of the main items of equipment were sent to potential vendors. Each enquiry included an appropriate Performance Specification, which called for a detailed equipment information summary and also asked for a budget price estimate. A less detailed enquiry was sent by telex to potential suppliers of specialized magnetic and electrical separation equipment, but only limited suppliers of this equipment exist at the present time. All other items of equipment were specified to potential vendors either by telex or telephone to obtain the required technical details and budget prices to permit selection.

Consequently, the mechanical equipment for the Deep Coal Cleaning Pilot Plant has been selected based on the following criteria:

(a) Best price and most technically suitable for the service required;
(b) Best price and a Canadian manufacturer selected in preference to an imported product;
(c) Selected on the basis that the equipment is the only one available for the service required. It may be that only one vendor was able to supply in the size or capacity range required.

The following Table 4.5-1 summarizes the evaluation of the various bids which were received by Kilborn in response to formal requests for equipment recommendation and corresponding budget price estimate. A price in Canadian funds FOB, Devon, has been calculated to allow a cost comparison to be made.

Sala (Canada) has offered a further 5 percent reduction in their prices of the ball mill, flotation cells, slurry pumps and wet drum magnetic separator if all of these items are purchased from them. This discount has, however, not been included in Table 4.5-1.

## TABLE 4.5-1

## MECHANICAL EQUIPMENT SELECTION

| EQUIP. NO. | DESCRIPTION | PRICE ($ CDN FUNDS FOB DEVON, ALTA.) | REASON |
|---|---|---|---|
| 10.10.07 | Crusher - Hammer-Type [Jeffrey selected on basis of best price quoted in Canada] | $ 9,415 | Two bids were received - one from Jeffrey at $9,116 (ex Montreal) and KHD at $44,220, TEMA declined to bid |
| 10.10.02 | Ball Mill 1800 mm Ø x 3600 mm Long [Sala were selected based on coal grinding exper., Canadian source, and a better price than Joy, when converted to Cdn. funds with duty and freight applied to Joy (Denver)] | $ 168,900 | Three bids received: KVS at $276,850 U.S.; Joy at $103,000 U.S.; Sala at $158,900 FOB Mississauga, Ontario |
| 20.15.01<br>20.15.02 | Primary and Secondary Flotation Cells [Sala were selected based on best price for Cdn. supplier; price included Blower Skid Mounted and evaluated better than Hazen in final design] | $ 89,900 | Three bids received: Hazen at $44,610 U.S.; Wemco at $99,257; Sala at $86,000 FOB Mississauga Ontario |
| 10.22.01<br>20.22.03<br>20.22.09 | Cyclones [Carpco-Wilfley Canada selected as most suitable for the application based on price] | $ 32,640 | Three bids received: KVS at $36,700; Cyclone Eng. at $31,185; Carpco at $24,480 U.S. funds |
| 10.63.01<br>10.63.02<br>20.63.03<br>20.63.04 | Slurry Pumps [The Sala price for the package includes Pump Boxes and Bases, and on | $ 51,676 | Three bids were received based on 5 pumps. On this basis, |

## TABLE 4.5-1 (CONT'D)

## MECHANICAL EQUIPMENT SELECTION

| EQUIP. NO. | DESCRIPTION | PRICE ($ CDN FUNDS FOB DEVON, ALTA.) | REASON |
|---|---|---|---|
| 20.63.06<br>20.63.08<br>20.63.09 | an evaluated price and for design considerations was selected] | | prices were as follows:<br>Wilfley $28,521<br>Warman $27,146<br>Sala $38,656 |
| 10.17.01<br>10.17.02 | Roll-Up Doors [Quotation obtained from Richards-Wilcox] | $ 3,000 | One bid obtained for estimate - One request. DSS may want Contractor to purchase |
| 20.31.01<br>20.82.10<br>20.31.02<br>20.82.11<br>20.31.03<br>20.82.12 | Conditioner Tanks c/w Agitators [Estimating price obtained from Galigher-Ash only] | $ 10,700 | One bid - Galigher-Ash. Three requests |
| 10.35.02 | Magnetic Separator [Bid obtained from Sala only as this item is the type and kind required for the process design] | $ 33,400 | One bid - Sala. Two requests |
| 50.34.01 | High Intensity Electrostatic Separator (Ex Mass., U.S.) [Carpco selected as Vendor preferred to meet process requirements] | $ 56,500 | One bid - Carpco. One request |
| 40.35.01 | High Gradient Magnetic Separator* [Boxmag selected based on price and meets spec.]<br>*Boxmag machine is a newly developed, higher gradient machine than the original WHIMS machine offered in the initial proposal. | $ 120,000 | Two bids received: Sala at $450,000 U.S. funds; Boxmag at $120,000. Two requests |

## TABLE 4.5-1 (CONT'D)

## MECHANICAL EQUIPMENT SELECTION

| EQUIP. NO. | DESCRIPTION | PRICE ($ CDN FUNDS FOB DEVON, ALTA.) | REASON |
|---|---|---|---|
| 10.44.01 | Jib Crane - 12 ft Radius [Demag selected for price estimate] | $ 4,150 | One bid - One request |
| 10.63.11<br>10.63.22 | Metering Pumps [BIF pumps chosen as a package complete with Tanks and Pump Mounts, I/C Mixers] | $ 24,523 | Two bids - Two requests (one late) |
| 10.62.01<br>10.62.02 | Exhaust Fan and<br>Pressurizing Fan | -<br>- | |
| 30.42.01 | High Speed In-Line Mixer | $ 25,500 | One bid received - One request. Rotequip Inc. Ottawa. Developed with NRC. |
| 30.42.02<br>30.42.03 | Low Speed Mixer and (Two Required) | $ 12,500 | One bid rec'd. One request. |
| 20.36.01 | Centrifuge [Bird chosen on basis of design and Cdn. source - Broadbent is U.K. supply, Penwalt is U.S. source] | $ 145,000 | Three bids received: Bird at $143,238; Broadbent at $190,717; Penwalt-Sharples at $115,000 (Ex U.S.) |
| 30.62.02 | Balling Pan - 6 ft Dia Disc Pelletizer [Teledyne picked as having best sized equip. for the Pilot Plant, other manufacturers are larger units and more expensive] | $ 30,573 | One bid received from Teledyne, Yorke, Penn. One request |

## TABLE 4.5-1 (CONT'D)

## MECHANICAL EQUIPMENT SELECTION

| EQUIP. NO. | DESCRIPTION | PRICE ($ CDN FUNDS FOB DEVON, ALTA.) | REASON |
|---|---|---|---|
| 30.11.01 | Screen - Sweco Model - 48 inch Dia [This unit sized for specific service in Pilot Plant] | $ 8,148 | One bid rec'd. Obtained from Sweco. One request |
| 30.82.15 | Steel Tank - 6 ft Dia by 6 ft High | $ 1,500 | Purchase locally (Edmonton) |
| 30.82.16 | Steel Tank - 6 ft Dia by 6 ft High | $ 1,500 | Purchase locally (Edmonton) |

All prices indicated in PRICE column are exclusive of FEDERAL SALES TAX, and where duty is not included, it will be shown in the final estimate. FST will be included as a single cost item for all equipment in the Capital Cost Estimate.

# 5.0 MECHANICAL ENGINEERING DESIGN

# 5.0 MECHANICAL ENGINEERING DESIGN

## 5.1 DRAWINGS

All mechanical engineering design drawings are included in Section 13.0 of this Report.

General arrangement drawings and plans demonstrating the layout of the Pilot Plant are included as Figures 5.01 to 5.12 in this section of the Report. These drawings are self-explanatory and show all pertinent constructional details. When proprietary equipment is ordered, certified drawings are issued and these will be required for producing final construction drawings. The Construction Contractor will, therefore, have the responsibility for checking and finalizing these drawings in accordance with certified equipment drawings and the drawings produced originally by Kilborn.

## 5.2 EQUIPMENT LOCATION

Great care and ingenuity has been exercised in the layout of equipment in the new Pilot Plant area, and the following factors have been taken into account:

(a) Access and safety;
(b) Minimized interruption of existing facilities;
(c) Minimized distance for pipework;
(d) Kilborn working standards on pipework and launder angles of slope;
(e) Provision for access for manual sampling;
(f) Provision for future automation;
(g) Constructability.

## 5.3 BUILDING SERVICES

In the mill area, a wall-mounted exhaust fan, which will be manually controlled, will relieve excess heat and humidity from this area. This fan will be of the propeller-type complete with back draft dampers and have bronze tipped steel impellers (AMCA, Class C, Sparkproof). It will be located above head height on the flotation floor level (i.e. below the new roof level). An explosion-proof unit heater will be available to heat the mill area at the ground floor elevation.

The new Motor Control Centre (MCC) will be pressurized with 100 percent tempered, filtered outdoor air. Outdoor air will be drawn through a wall louvre via filters using a cabinet fan. This fan will force air, via ducting, into the MCC room. An electrical duct heater will heat this air in response to a wall-mounted room thermostat. The blower motor in this fan will be explosion-proof, and the heater will be located within the pressurized room. All ducting will be internally insulated.

## 5.4 DUST AND FUME CONTROL

Any rerouting of dust ducting as a result of modifications to existing Pilot Plant layout should conform to the American Conference of Governmental Industrial Hygenists - Industrial Ventilation Recommendations. The reagent mixing tanks will be exhausted to the atmosphere through the roof utilizing an epoxy coated exhaust fan.

## 5.5 PAINTING

The painting specifications shall be the responsibility of the Owner.

All fabricated platework will be finished with one coat of primer, unless otherwise instructed by the Owner. Proprietary equipment will normally be to the manufacturer's standard finish, unless stated otherwise by the Owner.

It is assumed that the new sections of the Pilot Plant will be colour-coded in similar fashion to the existing sections, and this should be specified to the Construction Contractor by the Owner.

## 6.0 PIPING DESIGN

# 6.0 PIPING DESIGN

## 6.1 DRAWINGS

Piping drawings are described in Section 13.0. The format of the piping drawings is exactly the same as that used for flowsheet and general arrangement drawings to facilitate easy reference.

## 6.2 DESIGN

Piping should be to the Kilborn Piping Specifications No. 17-500-2 included in Appendix 'C', unless instructed otherwise by the Owner. These Piping Specifications include a Piping Line List and Valve Specifications and should, therefore, be read in conjunction with Piping Diagram Drawing No. 100-17-01. Pipe runs are shown on piping general arrangement drawings, but these drawings only show the proposed runs and are not detailed installation drawings. The precise and actual routings must be carried out by the Construction Contractor or site run by the Owner. Adequate space has been allowed for in the layout of the Pilot Plant to cater for minimized run lengths wherever practicable. All pertinent details regarding pipe runs, valve locations and hose stations are shown on the piping general arrangement drawings.

Kilborn has endeavoured to ensure that all pipelines are self-draining (one high point only), and standards for minimum angle of slope have been adhered to. All gravity piping will have the steepest slope possible to ensure that no obstruction of passageways or access to valves or equipment occurs. Kilborn recommends that a minimum of 2135 millimetre headroom be allowed beneath all piping, coverings and appurtenances, unless otherwise indicated on the drawings.

Any valves located above normal headroom should be fitted with extended spindle or light chain actuators or be fitted with a remote actuator for automated use.

## 6.3 PAINTING

The painting specifications shall be the responsibility of the Owner.

All fabricated pipework will be finished with one coat of primer, unless otherwise instructed.

Final colour-coding will be to the Owner's specification and will be indicated prior to award of the Construction Contract.

**KILBORN**

**PIPE LINE IDENTIFICATION**

# LINE LIST

| | | | | | |
|---|---|---|---|---|---|
| PREP. P.C. | DATE: MAR.'86 | PROJECT: SUPPLY & SERVICES CANADA | SERVICE | SERVICE CODE PSL·151 | REV. |
| CHKD. | DATE: | PROJ. No. 7813.15 | PROCESS SLURRY | | |
| APPD. | DATE: | AREA: DEEP COAL CLEANING. | | SHT. 1 OF 6 | |

| LINE IDENTIFICATION No. | | | | TO | FROM | P&I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT |
|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS |
| 50 | PSL | 151 | 01 | BALL MILL 10.10.01 | BALL MILL FEED PUMP 10.63.01 | 100 17.01 | | | | |
| 100 | PSL | 151 | 02 | CLASSIFYING CYCLONES 10.22.01 | BALL MILL DISCHARGE PUMP. 10 63.02 | | | | | |
| 200 | PSL | 151 | 03 | BALL MILL 10.10.01 | CLASSIFYING CYCLONES 10.22.01 | | | | | |
| 150 | PSL | 151 | 04 | MAGNETIC SEPARATOR 10.35.02 | CLASSIFYING CYCLONES 10.22.01 | | | | | |
| 150 | PSL | 151 | 05 | DEWATERING CYCLONE FEED PUMP 20.63.03 | MAGNETIC SEPARATOR 10.35.02. | | | | | |
| 100 | PSL | 151 | 06 | MAGNETICS DRUM | MAGNETIC SEPARATOR 10.35.02 | | | | | |
| 75 | PSL | 151 | 07 | DEWATERING CYCLONES 20.22.03 | DEWATERING CYCLONE FEED PUMP 20.63.03. | | | | | |
| 50 | PSL | 151 | 08 | HIGH GRADIENT MAG. SEPARATOR 40.35.01 | DEWATERING CYCLONE FEED PUMP 20.63.03. | | | | | |
| 75 | PSL | 151 | 09 | FEED PUMP 20.63.04. | DEWATERING CYCLONES 20.22.03. | | | | | |
| 100 | PSL | 151 | 10 | SPLITTER BOX 20.89.03 | DEWATERING CYCLONES 20.22.03. | | | | | |
| 100 | PSL | 151 | 11 | BALL MILL DISCHARGE PUMP 10.63.02 | SPLITTER BOX 20.89.03. | | | | | |
| 100 | PSL | 151 | 12 | FEED PUMP 20.63.04 | SPLITTER BOX 20.89.03 | | | | | |
| 50 | PSL | 151 | 13 | CONDITIONER 20.82.10 | FEED PUMP 20.63.04 | | | | | |
| 50 | PSL | 151 | 14 | CENTRIFUGE 20.36.01 | FEED PUMP 20.63.04 | | | | | |
| | | | | | | | | | | |
| 150 | PSL | 151 | 16 | CENTRIFUGE FEED PUMP 20.63.09. | CONDITIONER 20.82.10. | | | | | |
| 100 | PSL | 151 | 17 | CENTRIFUGE FEED PUMP 20.63.09 | PRIM. FLOTATION CELLS 20.15 01 | | | | | |
| 100 | PSL | 151 | 18 | EXISTING THICKENER | PRIM. FLOTATION CELLS 20.15.01 | | | | | |
| 100 | PSL | 151 | 19 | CENTRIFUGE FEED PUMP 20.63.09 | SEC. FLOTATION CELLS 20.15.02 | | | | | |
| 100 | PSL | 151 | 20 | 100.PSL.151.18 | SEC. FLOTATION CELLS 20.15.02. | | | | | |

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| DATE | REVISIONS | | | | |

KILBORN
PIPE LINE IDENTIFICATION

# LINE LIST

PREP. P.C. DATE: MAR'86 PROJECT: SUPPLY & SERVICES CANADA
CHKD. DATE: PROJ. No. 7813.15
APPD. DATE: AREA: DEEP COAL CLEANING

SERVICE: PROCESS SLURRY
SERVICE CODE: PSL 151
REV.
SHT. 2 OF 6

| LINE IDENTIFICATION No. | | | | TO | FROM | P & I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS | |
| 75 | PSL | 151 | 21 | CENTRIFUGE<br>20.36.01. | CENTRIFUGE FEED PUMP<br>20.63.09. | 100.17.01 | | | | | |
| 75 | PSL | 151 | 22 | HIGH SHEAR MIXER<br>30.42.01 | CENTRIFUGE FEED PUMP<br>20.63.09. | | | | | | |
| 150 | PSL | 151 | 23 | SEC. FLOTATION CELLS<br>20.15.01 | CONDITIONER<br>20.82.11 | | | | | | |
| 75 | PSL | 151 | 24 | THICKENING CYCLONES<br>20.22.09 | THICKENING CYCLONE<br>FEED PUMP 20.63.06 | | | | | | |
| 75 | PSL | 151 | 25 | DEWATERING CYCLONES<br>20.22.03. | CENTRIFUGE FEED<br>PUMP 20.63.09 | | | | | | |
| 75 | PSL | 151 | 26 | CONDITIONER<br>20.82.11. | THICKENING CYCLONES<br>20.22.09. | | | | | | |
| 100 | PSL | 151 | 27 | SPLITTER BOX<br>20.89.05 | THICKENING CYCLONES<br>20.22.09 | | | | | | |
| 100 | PSL | 151 | 28 | CONDITIONER<br>20.82.11. | SPLITTER BOX<br>20.89.05 | | | | | | |
| 100 | PSL | 151 | 29 | 100. PSL.151.18 | SPLITTER BOX<br>20.89.05 | | | | | | |
| 50 | PSL | 151 | 30 | H.G. MAG. SEP.<br>40.35.01 | FEED PUMP<br>20.63.04 | | | | | | |
| 50 | PSL | 151 | 31 | HIGH SHEAR MIXER<br>30.42.01 | FEED PUMP<br>20.63.04 | | | | | | |
| 100 | PSL | 151 | 32 | H.G.M.S. PRODUCT<br>PUMP. 40.63.08 | H.G. MAG. SEP.<br>40.35.01 | | | | | | |
| 100 | PSL | 151 | 33 | H.G.M.S. TAILINGS | H.G. MAG. SEP.<br>40.35.01 | | | | | | |
| 100 | PSL | 151 | 34 | LOW SHEAR MIXER<br>30.42.02 | HIGH SHEAR MIXER<br>30.42.01 | | | | | | |
| 100 | PSL | 131 | 35 | H.G.M.S. PRODUCT<br>PUMP 40.63.08 | LOW SHEAR MIXER<br>30.42.02. | | | | | | |
| 100 | PSL | 151 | 36 | 100.PSL.151.18 | SCREEN<br>30.11.01 | | | | | | |
| 200 | PSL | 151 | 37 | PELLETIZER<br>30.36.02 | SCREEN<br>30.11.01 | | | | | | |
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| 50 | PSL | 151 | 40 | CONDITIONER<br>20.82.10. | H.G.M.S. PRODUCT<br>PUMP 40.63.08. | | | | | | |

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**PIPE LINE IDENTIFICATION**

# LINE LIST

PREP. P.C. DATE: MAR '86 PROJECT: SUPPLY & SERVICES CANADA
CHKD. DATE:
APPD. DATE:
PROJ. No. 7813.15
AREA: DEEP COAL CLEANING.

SERVICE: PROCESS SLURRY
SERVICE CODE: PSL 151
REV.:
SHT. 3 OF 6

| LINE IDENTIFICATION No. | | | | TO | FROM | P & I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT |
|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS |
| 50 | PSL | 151 | 41 | CLEAN COAL CENTRIFUGE 20.36.01 | H.G.M.S. PRODUCT PUMP 40.63.08 | 100.17.01 | | | | |
| 100 | PSL | 151 | 42 | 100. PSL . 151 . 12 | CLEAN COAL CENTRIFUGE 20.36.01 | | | | | |
| 200 | PSL | 151 | 43 | COAL-WATER FUEL BIN, 20.89.07 | CONDITIONER 20.82.12 | | | | | |
| 100 | PSL | 151 | 44 | FINE COAL PRODUCT | COAL-WATER FUEL BIN. 20.89.07 | | | | | |
| 100 | PSL | 151 | 45 | FINE COAL PRODUCT | COAL-WATER FUEL BIN. 20.89.07 | | | | | |
| 100 | PSL | 151 | 46 | FINE COAL PRODUCT | CLEAN COAL CENTRIFUGE 20 36.01 | | | | | |

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**PIPE LINE IDENTIFICATION**

# LINE LIST

PREP. P.C. DATE: MAR '86 PROJECT: SUPPLY & SERVICES CANADA
CHKD. DATE: PROJ. No. 7813.15
APPD. DATE: AREA: DEEP COAL CLEANING

SERVICE: PROCESS WATER
SERVICE CODE: WPR 750
REV.
SHT. 4 OF 6

| LINE IDENTIFICATION No. | | | | TO | FROM | P & I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT |
|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS |
| 75 | WPR | 750 | 01 | BALL MILL FEED PUMP 10.63.01 | EXISTING MAKE-UP WATER TANK 4063 | 100.17.01 | | | | |
| 75 | WPR | 750 | 02 | BALL MILL DISCHARGE PUMP 10.63.02 | 75.WPR.750.01 | 100.17.01 | | | | |
| 50 | WPR | 750 | 03 | FEED PUMP 20.63.04 | 75.WPR.750.02 | 100.17.01 | | | | |
| 75 | WPR | 750 | 04 | THICKENING CYCLONE FEED PUMP 20.63.06 | 75.WPR.750.02 | 100.17.01 | | | | |
| 50 | WPR | 750 | 05 | H.G.M.S. PRODUCT PUMP 40.63.08 | 75.WPR.750.04 | 100.17.01 | | | | |

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**PIPE LINE IDENTIFICATION**

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**PREP.** P.C. **DATE:** MAR '86 **PROJECT:** SUPPLY & SERVICES CANADA
**CHKD.** **DATE:** **PROJ. No.** 7813.15
**APPD.** **DATE:** **AREA:** DEEP COAL CLEANING

**SERVICE** FRESH WATER

**SERVICE CODE** WFR 750 **REV.**

**SHT.** 5 **OF** 6

| LINE IDENTIFICATION No. | | | | TO | FROM | P & I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT |
|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS |
| 50 | WFR | 750 | 01 | CONDITIONER<br>20 . 82 . 12 | FRESH WATER SUPPLY | 100.17.01 | | | | |
| 75 | WFR | 750 | 02 | H. G. MAG. SEP<br>40 . 35 . 01 | FRESH WATER SUPPLY | 100.17.01 | | | | |
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**REVISIONS**

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**PIPE LINE IDENTIFICATION**

# LINE LIST

PREP. P.C. DATE: MAR.'86 PROJECT: SUPPLY & SERVICES CANADA
CHKD. DATE: PROJ. No. 7813.15
APPD. DATE: AREA: DEEP COAL CLEANING.

SERVICE: BLOWER AIR
SERVICE CODE: AB 701
REV.
SHT. 6 OF 6

| LINE IDENTIFICATION No. | | | | TO | FROM | P & I.D. REF. | REMARKS | TEST DATA | INSUL'T | PAINT |
|---|---|---|---|---|---|---|---|---|---|---|
| NOM. SIZE | SERV. CODE | PIPE SPEC. | LINE No. | | | | | PRESS. & MEDIUM | SPEC. | CLASS |
| 75 | AB | 701 | 01 | FLOTATION CELLS<br>20.15.01 & 20.15.02. | AIR BLOWER | 100.17.01. | | | | |
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REVISIONS

## 7.0 STRUCTURAL AND CIVIL ENGINEERING DESIGN

# 7.0 STRUCTURAL AND CIVIL ENGINEERING DESIGN

## 7.1 DRAWINGS

Drawings of structural, civil and architectural design details are described in Section 13.0.

This cannot be finalized for construction until the equipment purchase is finalized and certified vendor drawings are obtained. This will be the responsibility of the Construction Contractor.

## 7.2 DESIGN

Structural-civil design work includes the following:

(a) New ball mill foundation;
(b) Accommodation of the ball mill in an area with concrete block walls and accessed by two rolling steel doors;
(c) Grating floor at an elevation of 103,600 millimetres to support the wet drum magnetic separator;
(d) Grating floor at an elevation of 104,600 millimetres to support the ball feed bin, classifying cyclones and pumps;
(e) Grating floor at an elevation of 107,500 millimetres to support the flotation cells;
(f) Concrete floor at an elevation of 107,500 millimetres (in the existing Pilot Plant) to protect the existing MCC from water damage and to accommodate the HGMS and oil agglomeration equipment;
(g) Steelwork floor modifications at both floor levels in the existing Pilot Plant to accommodate solid-bowl centrifuge and coal-water mixing tanks;
(h) New MCC on the ground floor of the existing Pilot Plant.

## 7.3 PAINTING

The painting specifications shall be the responsibility of the Owner.

All structural steelwork will be finished with one coat of primer, unless otherwise instructed by the Owner or Construction Contractor.

# 8.0 ELECTRICAL ENGINEERING DESIGN

# 8.0 ELECTRICAL ENGINEERING DESIGN

## 8.1 DRAWINGS

Single-line electrical drawings covering all areas of the Deep Coal Cleaning Pilot Plant are included in Section 13.0.

## 8.2 POWER DISTRIBUTION SYSTEM

Space in the existing Motor Control Centre (MCC) in the Pilot Plant control room will be utilized to feed new equipment. All motors on this MCC will be 480 VAC and will utilize across-the-line starting.

For the remaining motors, a new vertical section with three equipped spaces and a breaker is to be installed in the main building switchgear to feed the new MCC being installed in the new electrical room located below the existing Pilot Plant control room. All motors on the MCC shall be 575 V.

A closed transition auto transformer reduced voltage starter will be installed for the 200 horsepower motor to prevent excessive voltage drop during starting which may disturb sensitive instruments and computer systems. All remaining motors on this MCC will utilize across-the-line starting.

A 120/208 distribution panel will provide power for lighting and small metering pump motors.

## 8.3 CONTROL SYSTEM

The control system will utilize a Programmable Logic Controller (PLC) system with a simple CRT display and keyboard controls. The PLC will be programmed for each of the various possible operating schemes; and by using the CRT display and keyboard, the operating scheme can be selected and a group start or stop initiated. A printer will be provided to print alarms or status messages.

## 8.4 BASIC MATERIALS AND METHODS

All equipment located within clean electrical and/or control rooms will utilize general purpose EEMAC 1 enclosures.

Equipment in process areas, i.e. motor control stations, and lighting, will be rated for Class 1, Division 1, Group F hazardous locations.

All distribution within the building will use type Teck HL (hazardous locations) cable in tray and/or clipped to steelwork as required.

## 8.5 LIGHTING

Lighting will utilize High Pressure Sodium (HPS) fixtures in process areas with maintained lighting levels of approximately 30 FC. Fluorescent-type fixtures will be used in the new electrical room.

# 9.0 INSTRUMENTATION AND CONTROL DESIGN

# 9.0 INSTRUMENTATION AND CONTROL DESIGN

## 9.1 DRAWINGS

Instrumentation drawings are listed in Section 13.0 The format adopted is similar to that employed for piping design.

Finalization of these drawings cannot be concluded until vendor information becomes available following equipment purchase. Because this is likely to be a phased form of development with progressive installation of control equipment over a period of time, Kilborn recommends that, as far as practicable, installation drawings be prepared by the Construction Contractor to include basic manual control from the control console at the outset.

## 9.2 DESIGN

Level alarms in pump boxes provide for high and low indication, and sensors of the conductivity type are recommended.

The water addition to the ball mill feed pump box is controlled to respond to a pre-set relative density of feed slurry.

The level in the classifying cyclone feed pump box is controlled to maintain constant cyclone feed pressure.

An on-line particle size analyzer is recommended for monitoring the size distribution of the classifying cyclone overflow. This device will provide an instant read-out of percent maximum and percent minimum solids at specific cutpoint size, and is located after the wet drum magnetic separator because magnetic particles may have a detrimental effect upon accuracy.

Reagent addition to the flotation cells is controlled via positive displacement type metering pumps, responding to a signal from the dewatering cyclone feed density. Alternatively, addition can be controlled by a computed solids flow value obtained from the density and flow gauge signals. The metering pumps may be manually pre-set to a minimum/maximum feed rate setting once the reagent combinations have been selected.

Flotation cell level is controlled by a dart valve assembly in conjunction with automatic level control, including a level control probe and an electric actuator. This is supplied and installed in each cell bank by the flotation cell vendor.

The underflow of the coal-water conditioner is controlled by a pinch-type flow control valve, and monitored by a nuclear density gauge. A constant relative density coal-water mixture can then be maintained by process water addition in a retroactive circuit.

The coal-water bin is continuously weighed by means of electronic load cells, and the mass of mixture prepared is recorded on a chart recorder.

All density gauges employed are of the nuclear type and the electronics are microprocessor-based and field programmable. Density gauges D1T 1002, D1T 1004 and D1T 2003 have a mass-flow computer which provides a rate input in dry tonnes per hour and a total tonnes integrator. Flow meters are DC magnetic type meters.

Controllers and recorders are microprocessor-based, analogue type which are computer compatible and field programmable. They will be mounted in a desk type of control console located in the existing control station in the existing MCC room.

Alarms shall be connected to the input rack of the programmable controller and logged by a printer.

The programmable process controllers may initially be operated as conventional PID controllers, and can be programmed to perform any of the required functions described earlier. Included in the control console estimate is a communication link and power supply, together with an interface board to communicate with the PLC and status display system. Communication with other computers is also possible.

With this link, the individual controllers may be sequenced for automatic plant start-up and shut-down, and setpoints can be changed from the keyboard or automatically by the PLC program.

Each recorder provides an indication of trending of up to three variables and alarm logging. Configurable chart speeds and ranges are readily changed by operating personnel.

## 9.3 INSTRUMENT INDEX

The following index identifies the instrumentation which Kilborn has selected for the Deep Coal Cleaning Pilot Plant:

| REMARKS | P.O. OR REQ. No. | INSTR. SPEC. No. | J. BOX DWG. No | INSTALLATION DETAIL DWG. No |  |  |  |  | LOCAT. DWG. No. | LOOP DIA. No. | INSTR. LOCAT./ TYPE |  | FLOW DIA. OR P & ID No. | LINE OR EQUIPMENT NUMBER | SERVICE OR DESCRIPTION | INSTRUMENT TAG NUMBER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | WINTER | PNEU | ELEC | MOUNT | PROCESS |  |  | CP LP FL | P F |  |  |  |  |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  | FL |  | 100-18-01 | 10-63-01 | ELECTRODE HOLDER WITH | LE 1001 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | HIGH & LOW ELECT. |  |
| A/B 2/30 |  |  |  |  |  |  |  |  |  |  | MCC |  | 100-18-01 | 10-63-01 | CONTROL RELAY | LS 1001 |
| " |  |  |  |  |  |  |  |  |  |  |  | PC | 100-18-01 | 10-63-01 | LEVEL ALARM HIGH | LAH 1001 |
|  |  |  |  |  |  |  |  |  |  |  |  | PC | 100-18-01 | 10-63-01 | LEVEL ALARM LOW | LAH 1001 |
| OHART D3400 |  |  |  |  |  |  |  |  |  |  | FL |  |  | 50 PSL 151-01 | GAMMA SOURCE | DX 1002 |
| " " |  |  |  |  |  |  |  |  |  |  | FL |  |  | 50 PSL 151-01 | GAMMA DETECTOR | DE 1002 |
| " |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | TRANSMITTER/COMPUTER | DIT 1002 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | CONTROLLER | DIC 1002 |
| FISHER 546 |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | I/P CONVERTER | DY 1002 |
| FISHER MBR 667-30-EZ |  |  |  |  |  |  |  |  |  |  | FL |  |  | 50 WPR 750-01 | CONTROL VALVE | DCV 1002 |
| TURANT |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | DRY TON TOTALIZER | QI 1002 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | DRY TON RATE REC. | QR 1002 |
| BROOKS WAFER |  |  |  |  |  |  |  |  |  |  | FL |  |  | 50 PSL 151-01 | MAG. FLOW METER | FT 1002 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | FLOW RECORDER | FR 1002 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MILTRONICS |  |  |  |  |  |  |  |  |  |  | FL |  |  | 10-63-02 | ULTRASONIC TRANSDUCER | LE 1003 |
| MINI RANGER |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | TRANSMITTER | LIT 1003 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | INDICATING CONTROLLER | LIC 1003 |
| FISHER 546 |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | I/P CONVERTER | LY 1003 |
| " MBR 667-30-EZ |  |  |  |  |  |  |  |  |  |  | FL |  |  | 75 WPR 750-02 | CONTROL VALVE | LCV 1003 |

| REFERENCE DWG'S |  | REVISION |  |  |  |
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| SECTION | INSTR. |  | PROJECT No | DIVISION No |
|---|---|---|---|---|
| SCALE |  | DATE | 7813 | 15 |
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| REMARKS | P.O. OR REQ. No | INSTR. SPEC. No. | J. BOX DWG. No. | INSTALLATION DETAIL DWG No | | | | | LOCAT. DWG. No. | LOOP DIA. No. | INSTR. LOCAT./ TYPE | | FLOW DIA. OR P & ID No. | LINE OR EQUIPMENT NUMBER | SERVICE OR DESCRIPTION | INSTRUMENT TAG NUMBER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | WINTER | PNEU. | ELEC. | MOUNT | PROCESS | | | CP<br>LP<br>FL | P<br>F | | | | |
| QMART D3400 | | | | | | | | | | | | | 100-18-01 | 100-PSL-151-02 | GAMMA SOURCE | DX 1004 |
| " | | | | | | | | | | | | | | " | GAMMA DETECTOR | DE 1004 |
| QMART 2 UDP | | | | | | | | | | | MCC | | | | DENSITY TRANS. COMPUT. | DIT 1004 |
| DURANT | | | | | | | | | | | CP | F | | | DRY TON TOTALIZER | QI 1004 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | DRY TON RATE REC. | QR 1004 |
| BROOKS WAFER | | | | | | | | | | | FL | | | | FLOW TRANSMITTER | FT 1004 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | FLOW RECORDER | FR 1004 |
| | | | | | | | | | | | | | | | | |
| U.S. GAUGE | | | | | | | | | | | FL | | | 10-22-01 | PRESSURE GAUGE | PI 1005 |
| DIAPHRAGM SEAL | | | | | | | | | | | | | | | | |
| UNILOCK | | | | | | | | | | | FL | | | | PH SENSOR | AE 1006 |
| " 1050 | | | | | | | | | | | MCC | | | | PH INDICATOR TRANSMIT. | AIT 1006 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | CONTROLLER | AIC 1006 |
| FISHER 546 | | | | | | | | | | | FL | | | | I/P CONVERTER | AY 1006 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | RECORDER | AIR 1006 |
| | | | | | | | | | | | | | | | | |
| R S1 | | | | | | | | | | | | | | 10-10-02 | AC 0-5AT04-20m$^A$ | JT 1007 |
| | | | | | | | | | | | | | | | CONVERTER | |
| TAYLOR MOD 30 | | | | | | | | | | | | | | | POWER RECORDER | JR 1007 |
| | | | | | | | | | | | | | | | | |
| B/W CONTROLS | | | | | | | | | | | FL | | | 20-63-03 | ELECTRODE HOLDER | LE 2001 |
| | | | | | | | | | | | | | | | WITH HIGH & LOW ELECTR. | |
| | | | | | | | | | | | MCC | | | | CONTROL RELAY | LS 2001 |
| | | | | | | | | | | | | | | | | |
| ARMCO | | | | | | | | | | | FL | | | 75-PSL-151-07 | PARTICLE SIZE | AE 2002 |
| AUTOMETRICS | | | | | | | | | | | | | | | SENSOR | |
| | | | | | | | | | | | MCC | | | | ELECTRONIC | AIT 2002 |
| | | | | | | | | | | | | | | | PARTICLE SIZE | |
| | | | | | | | | | | | | | | | TRANSMITTER | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OHMART D3500 | | | | | | | | | | | FL | | 100-18-01 | 75-PSL-151-07 | GAMMA SOURCE | DX 2003 |
| " | | | | | | | | | | | FL | | | | GAMMA DETECTOR | DE 2003 |
| OHMART 2 UDP | | | | | | | | | | | MCC | | | | DENSITY TRANS. COMPUT. | DIT 2003 |
| DURANT | | | | | | | | | | | CP | F | | | DRY TON TOTALIZER | QI 2003 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | DRY TON RATE RECORD. | QR 2003 |
| BROOKS WAFER | | | | | | | | | | | FL | | | | FLOW TRANSMITTER | FT 2003 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | FLOW RECORDER | FR 2003 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | REAGENT CONTROLLER | FIC 2004 |
| RIS | | | | | | | | | | | FL | | | | CURRENT | FY 2004A |
| | | | | | | | | | | | | | | | ISOLATORS | FY 2004B |
| | | | | | | | | | | | | | | | | FY 2004C |
| | | | | | | | | | | | | | | | | FY 2004D |
| | | | | | | | | | | | | | | | | FY 2004E |
| | | | | | | | | | | | | | | | | FY 2004F |
| | | | | | | | | | | | | | | 20-22-03 | PRESSURE GAUGE | PI 2005 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | MANUAL POSITION CONT. | ZC 2006 |
| FISHER 546 | | | | | | | | | | | FL | | | | I/P CONVERTER | ZY 2006 |
| FOXBORO | | | | | | | | | | | FL | | | | POSITION ACTUATOR | ZV 2006 |
| ASCO | | | | | | | | | | | FL | | | | HAND VALVE | HV 2006 |
| FISHER 76F | | | | | | | | | | | FL | | | | PRESSURE REGULATOR | HC 2006 |
| OHMART D3500 | | | | | | | | | | | PL | | | 20-63-04 | GAMMA SOURCE | DX 2007 |
| " | | | | | | | | | | | FL | | | | GAMMA DETECTOR | DE 2007 |
| OHMART 2 UDP | | | | | | | | | | | MCC | | | | DENSITY TRANSMIT. | DIT 2007 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | DENSITY RECORDER | DR 2007 |
| BROOKS WAFER | | | | | | | | | | | FL | | | | FLOW TRANSMITTER | FT 2007 |
| TAYLOR MOD 30 | | | | | | | | | | | CP | F | | | FLOW RECORDER | FR 2007 |

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|  |  |  |  | WINTER | PNEU. | ELEC. | MOUNT | PROCESS |  |  | CP LP FL | P F |  |  |  |  |
| [redacted] |  |  |  |  |  |  |  |  |  |  | FL |  | 100-18-01 | 20-63-04 | ELECTRODE HOLDER | LE 2008 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | WITH HIGH & LOW ELECT. |  |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | CONTROL RELAY | LS 2008 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| UNILOC |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-82-10 | pH SENSOR | AE 2009 |
| " |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | pH INDICATOR | AIT 2009 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | TRANSMITTER |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-63-09 | ELECTRODE HOLDER | LE 2010 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | WITH HIGH & LOW ELECT. |  |
| " |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | CONTROL RELAY | LS 2010 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-63-06 | ELECTRODE HOLDER | LE 2011 |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  |  |  |  |  | C/W HIGH & LOW ELECTR. |  |
| " |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | CONTROL RELAY | LS 2011 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| UNILOC |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-82-11 | pH SENSOR | AE 2012 |
| " |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | pH INDICATOR | AIT 2012 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | TRANSMITTER |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| U.S. GAUGE |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-22-09 | PRESSURE GAUGE | PI 2013 |
| DIAPHRAGM SEAL |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-82-12 | ELECTRODE HOLDER | LE 2014 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | C/W HIGH & LOW ELECT. |  |
| " |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | CONTROL RELAY | LS 2014 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  | 20-89-05 | MANUAL POSITION CONTR. | ZC 2015 |
| FISHER 546 |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | I/P CONVERTER | ZY 2015 |
| FOXBORO |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | POSITION ACTUATOR | ZY 2015 |
| ASCO |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | HAND VALVE | HV 2015 |
| FISHER 76F |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | PRESSURE REGULATOR | HC 2015 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | WINTER | PNEU. | ELEC. | MOUNT. | PROCESS |  |  | CP<br>LP<br>FL | P<br>F |  |  |  |  |
| OHART |  |  |  |  |  |  |  |  |  |  | FL |  | 100-18-01 | 200-PSL-151-43 | GAMMA SOURCE | DX 2016 |
| " |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | GAMMA DETECTOR | DE 2016 |
| OHART 2 UDP |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | DENSITY TRANSMITTER | DIT 2016 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | DENSITY CONTROLLER | DIC 2016 |
| FISHER 546 |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | I/P CONVERTER | DY 2016 |
| RED VALVE (PINCH) |  |  |  |  |  |  |  |  |  |  | FL |  |  | 200-PSL-151-43 | CONTROL VALVE | DV 2016 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | DENSITY RECORDER | DR 2016 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| BOFORDS ELECTRONIC |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-89-07 | LOAD CELLS | WE 2017 |
| " |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | LOAD CELL TRANSMIT. | WIT 2017 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | WEIGHT RECORDER | WR 2017 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| B/W CONTROLS |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | ELECTRODE HOLDER | LE 2018 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | C/W HIGH ELECTRODE |  |
|  |  |  |  |  |  |  |  |  |  |  | MCC |  |  |  | CONTROL RELAY | LS 2018 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| BROOKS WAFER |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-63-09 | FLOW TRANSMITTER | FT 2019 |
| TAYLOR MOD 30 |  |  |  |  |  |  |  |  |  |  | CP | F |  |  | FLOW RECORDER | FR 2019 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SUPPLIED WITH |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-15-01 | LEVEL TRANSMITTER | LE 2020 |
| FLOTATION |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | LEVEL CONTROLLER | LIC 2020 |
| CELLS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | FL |  |  | 20-15-02 | LEVEL TRANSMITTER | LE 2021 |
|  |  |  |  |  |  |  |  |  |  |  | FL |  |  |  | LEVEL CONTROLLER | LIC 2021 |

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REVISION

| No | DESCRIPTION | DATE | BY | PROJ. | CLIENT |
|---|---|---|---|---|---|

CLIENT SUPPLY & SERVICES CANADA

LOCATION DEVON COAL RESEARCH CENTRE

INSTRUMENT LIST

KILBORN

| SECTION | INSTR. |  | PROJECT No | DISCIPLINE No |
|---|---|---|---|---|
| SCALE |  | DATE | 7813 | 15 |
| DRAWN |  |  | DRAWING NUMBER | REV |
| CHECKED |  |  | B 100-18-02 | 0 |
| APPROVED |  |  | SHEET 5 OF 5 |  |

FORM KE-0-10-2 REV 0

## 10.0 FABRICATION AND CONSTRUCTION CONSIDERATIONS

# 10.0 FABRICATION AND CONSTRUCTION CONSIDERATIONS

## 10.1 CONSTRUCTION PHASES

In the Final Project Progress Meeting, it was decided that the Deep Coal Cleaning Pilot Plant would be constructed in the following phases:

Phase I
- Completion of the new plant extension (including steelwork, flooring, concrete foundations and bases, and all normal building services).
- Installation of the ball mill, classifying cyclones, drum magnetic separator, dewatering cyclones, solid-bowl centrifuge, coal-water mixing and storage units, and all associated pumps, pipework and valves, and electrical equipment, etc.
- Installation of manual control with instrumentation limited to bare essentials.

Phase II
- Installation of primary and secondary froth flotation cells, conditioning tanks, thickening cyclones, all metering pumps, and subsequent installation of oil agglomeration equipment with the possible exclusion of dewatering screen and pelletizing disc and ancillaries.
- Installation of the above includes all associated pumps, pipework and valves, and electrical equipment, etc.
- Installation of the above also includes essential instrumentation and control equipment, and probably the programmable controller and interface equipment.

**Phase III** - Installation of the HGMS together with all ancillaries including pumps, pipework and valves, and electrical equipment, etc.

- Subsequent installation of the HIES together with feed and product handling system, and all ancillary equipment. This includes finishing of the pressurized room and provision for remote monitoring from the control console.
- Installation of any remaining oil agglomeration circuit equipment.
- Finalization of instrumentation-control automation systems and introduction of all remote control loops described in Section 9.0 of this Report.

## 10.2 CONSTRUCTION FORMAT

The mechanical drawings were prepared with the following construction format, and this should be given consideration during construction scheduling:

(a) The ball mill must be positioned before new floor steelwork and walls are erected in order to fully utilize the existing 10-tonne SWL overhead crane in the CMRC Pilot Plant.

(b) Floor levels at an elevation of 107,500 millimetres is then erected and equipment installed using the crane. Equipment on floor elevation of 107,500 millimetres above the control room in the existing Pilot Plant has been designed to be on skids to facilitate the most effective arrangement on the new concrete floor.

(c) Other proprietary equipment, e.g. flotation cell air blower, should be specified as being skid mounted for ease of installation.

(d) Certified drawings of pumps/pump boxes require to be checked against steelwork drawings for clearance and hold-down bolt positions, etc.

(e) A final check on the position of safety facilities, i.e. emergency stop buttons, eyewash facilities, etc., should be conducted prior to issue of construction drawings.

## 10.3 PAINTING

Kilborn can provide, if required, a suitable painting specification for the new works, but it has been assumed that painting will be to the specifications of the Owner. One coat of primer is recommended for all fabricated platework and structural members, and this must be touched-up if on-site modifications are made prior to final finish painting.

Colour coding of pipework and, where relevant, process equipment is strongly recommended, and this should be carried out to the Owner's specification.

# 11.0 CAPITAL COST ESTIMATE

# 11.0 CAPITAL COST ESTIMATE

## 11.1 SUMMARY

The following Table 11.1-1 summarizes the Capital Cost Estimate for the complete Deep Coal Cleaning Pilot Plant, including all phases of construction and the installation of all process circuits described in this Report:

TABLE 11.1-1

CAPITAL COST ESTIMATE

| Description | Cost, Canadian $ |
|---|---|
| Excavation and Concrete | $ 80,657 |
| Structural Steel | 29,650 |
| Architectural | 22,185 |
| Mechanical (Including Equipment) | 1,089,962 |
| Piping | 156,271 |
| Instrumentation | 245,554 |
| Electrical | 236,417 |
| SUBTOTAL - DIRECT COSTS | $ 1,860,696 |
| Construction Costs (Total) | 235,154 |
| SUBTOTAL - INDIRECT COSTS | $ 235,154 |
| Additional Engineering to Modify Kilborn Drawings on Receipt of Certified Vendor Drawings | $ NOT INCLD. |
| Contingency at 10 Percent | 209,585 |
| TOTAL ESTIMATED COST | $ 2,305,435 |

## 11.2 CONSTRUCTION PHASES

The exact nature of the construction phases for the Project is unknown. However, in order to provide some indication of cash flow requirements for each of the three phases as described in Section 10.0 of this Report, the estimated costs could be subdivided in accordance with the content of each phase, i.e. Phase I, Phase II and Phase III. At the present time, it is not possible to specify these proportions without further careful review of the content of each phase. This should be done at a later date utilizing the detailed Capital Cost Estimate back-up sheets supplied by Kilborn with the attachments to this Report.

## 11.3 BASIS OF ESTIMATE

### 11.3.1 Scope Definition

The Scope of Work and battery limits of the Capital Cost Estimate are described in the flowsheets included in Section 3.0 of this Report, and in the drawings listed in Section 13.0. These limits are in accordance with the Scope of Work as described on pages 2 and 3 of Appendix 'A' in the DSS Contract No. 03SQ.23440-4-9227.

The estimate is also based on the following information:

(a) Plant design criteria outlined by the Scientific Authority and Kilborn;
(b) Equipment lists (included in Appendix 'B' and described in Section 3.0 of this Report);
(c) Equipment specifications and written or telephone quotations for major equipment items (see Appendix 'C' and 'D');
(d) Current vendors' list prices and in-house data for all remaining equipment;

(e) Mechanical specifications for equipment pricing from recent historic data.

The Capital Cost Details, as summarized earlier, list the cost areas into which the estimate is divided. Detailed back-up sheets are submitted with the attachments to this Report.

### 11.3.2 Material Quantities

Quantities were developed whenever possible from the design drawings, supplemented by design sketches and confirmed by in-house historic data from similar projects. Factors were applied where necessary for certain site-specific conditions.

## 11.4 CRITERIA

### 11.4.1 General

The estimate is based on the mid-1986 price level for equipment, materials and construction labour. Escalation beyond this has been excluded. Capital costs are expressed in Canadian dollars. All equipment and materials are FOB Project Site and include freight and delivery costs. Import duties on equipment are included if required. A currency exchange rate of 39 percent has been used for equipment quotations expressed in U.S. dollars.

### 11.4.2 Equipment

The majority of equipment prices have been obtained from written, telex and verbal vendor quotations supplemented by current in-house information on similar projects for which quotations, bid analyses and purchase orders are available.

### 11.4.3 Permanent Materials

Material prices recently compiled for similar plants in the area formed the primary data base.

### 11.4.4 Construction Labour

The estimate assumes a standard work week of 40 hours; five 8-hour shifts; Monday to Friday. The average construction labour rate is based on current rates of pay in the northern Alberta area for a metal crafts journeyman. For the purpose of this estimate, an average labour rate of $23 per man-hour has been used. This rate includes base rate and 27 percent fringe benefits.

### 11.4.5 Taxes

Federal sales tax has been included where applicable.

### 11.4.6 Indirects

The Construction Indirect Account has been developed from the direct field costs for this Project, and comprises, but is not limited, to the following:

(a) Mobilization and Demobilization;
(b) Course of Construction Insurance;
(c) Contractor Performance Bonds;
(d) Construction Equipment Rental and Maintenance;
(e) Temporary Construction Facilities;
(f) Contractor's Support Services;
(g) Off-Loading and Storage of Process Equipment;
(h) Final Clean-Up.

### 11.4.7 Escalation

Escalation beyond first quarter 1986 levels is excluded.

### 11.4.8 Accuracy

The estimate is considered to be accurate within plus or minus 15 percent.

### 11.4.9 Contingency

A contingency of 10 percent of the direct cost is included for the purpose of this estimate.

## 11.5 QUALIFICATIONS

The estimate provides for construction by lump sum firm price contracts, and is based on a continuous construction program (i.e. not subdivided into phases).

It is assumed that qualified tradesmen and supervisors employed by independent general contractors will perform the construction work on-site.

All equipment and permanent materials are considered to be purchased new.

## 11.6 EXCLUSIONS TO THE CAPITAL COST ESTIMATE

(a) Cost of site acquisition, leases or rental easements, rights-of-way, water rights.
(b) Cost of Federal and Provincial Government development bonds and permits.
(c) Costs incurred to date for feasibility studies, test work, investigations, consultants, including cost of present Design Study.

(d) Environmental impact studies or additional costs resulting from such studies.

(e) Property taxes to date.

(f) Facilities for future production expansion.

(g) Standby equipment, except as shown on the flowsheets.

(h) Commissioning and start-up expense beyond proof of mechanical operability.

(i) Legal and accounting costs.

(j) Owner's administration expense.

(k) Cost of financing and interest during construction.

(l) Working capital.

(m) Security guard service during construction.

(n) Premium time for multiple shifts and overtime, if required, by construction forces.

(o) Any loss of production to existing facilities during construction and tie-ins.

(p) Modifications to existing coal preparation facilities other than noted in the estimate details.

(q) Standby diesel electrical power generating equipment.

(r) Royalties on patented equipment.

(s) Extensions to main control room, laboratory, washroom facilities, etc.

(t) Modifications, if required, to existing incoming electrical power services to plant site;

(u) Modifications to existing services such as water supply system, compressed air system, effluent disposal system, etc.

(v) Spare parts, fuels, reagents, lubricant, ball charge, etc.

# 12.0 CONCLUSIONS AND RECOMMENDATIONS

# 12.0 CONCLUSIONS AND RECOMMENDATIONS

## 12.1 DESIGN CRITERIA

The design of the Deep Coal Cleaning Pilot Plant for ECRL is a 'state-of-the-art' design for which only limited previous design criteria have been obtained. As much use as possible has been made of the limited information which was obtained during the Phase I - Information Collection Stage of the Project. Although assistance was received from other coal-liquid mixture and deep cleaning pilot plant operators, much of this type of pilot-plant development is still under way. Kilborn, in close association with the Scientific Authority, has identified several key areas where laboratory testing is needed to confirm design values that have been assumed during the design. These key areas of further laboratory examination are:

(a) Wet ball milling of various coal types to identify the size distribution requirements for coal-water mixture preparation - this should be carried out using a laboratory scale closed-circuit ball mill.

(b) Cyclone thickening of ultra-fine milled coal to determine maximum achievable values of underflow solids concentration and corresponding overflow solids loss - this should be carried out using a closed-circuit laboratory cyclone rig.

(c) Coal-water stabilization and reagent addition tests - these should be carried out with 20-30 litre quantities. Testing of various methods of mixing-in the stablilizing agents is also required to establish optimized conditions for agitation speed and mixing time. This should be carried out with larger quantities in a tank fitted with a variable speed impeller.

(d) Thermal drying of ultra-fine coal in dense slurry form to obtain free-flowing powder - this should be carried out with small-scale dryers of commercial design.

(e) Thickener settling and clarification tests to determine required solids handling capacity ranges for ultra-fine colloidal material resulting from beneficiation of milled coal - this should be carried out using jar tests.

(f) HGMS and electrical separation tests. Ascertain latest findings of test programs carried out by the Coal Research Laboratories in Ottawa where this work has been in progress for several years.

## 12.2 FUTURE EXPANSION

Because it was possible to obtain a new area for accommodating the Deep Coal Cleaning Pilot Plant, and due also to the fact that this area is a natural extension of the existing Pilot Plant, future expansion in both areas remains feasible.

Kilborn has taken into account for further addition to the existing Pilot Plant of a secondary flotation cell bank, coal cleaning spiral and table circuits, and space exists for future addition of these circuits. Space also exists for future introduction of remotely controlled sampling points and other forms of automated control equipment.

# 13.0 DRAWINGS

## 13.0 DRAWINGS

| DRAWING NO. | REVISION | TITLE |
|---|---|---|
| 100-10-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>General Overall Flowsheet |
| 100-10-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>General Arrangement Plans |
| 100-10-03 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>General Arrangement Plans |
| 100-10-04 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>General Arrangement Sections |
| 100-10-05 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 1<br>Coal Grinding Only<br>Coal Water Fuel |
| 100-10-06 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 2<br>Two-Stage Flotation<br>Coal-Water Fuel |
| 100-10-07 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 3<br>Reverse Flotation<br>Coal-Water Fuel |
| 100-10-08 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 4<br>Oil Agglomeration |
| 100-10-09 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 5<br>Oil Agglomeration<br>With Single-Stage Flotation |

| DRAWING NO. | REVISION | TITLE |
|---|---|---|
| 100-10-10 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 6<br>Single-Stage Flotation<br>With Oil Agglomeration |
| 100-10-11 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 7<br>HGMS Cleaning<br>With Single-Stage Flotation |
| 100-10-12 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Flowsheet Option No. 8<br>HIE Separation<br>With Single-Stage Flotation |
| 100-10-13 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Preliminary Flowsheet |
| 100-11-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Plans, Elevations and Miscellaneous Details |
| 100-11-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>New MCC Room<br>Plans and Section |
| 100-14-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>General Notes and Miscellaneous Details |
| 100-14-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Floor and Roof Plans |
| 100-15-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Ball Mill Foundation<br>and Miscellaneous Details |
| 100-16-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Crusher Feed and Alternate Feed Bin Details |

| DRAWING NO. | REVISION | TITLE |
|---|---|---|
| 100-16-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Cyclopac Arrangements and Splitter Feed Details |
| 100-16-03 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Centrifuge Chutes and Coal Water Fuel Bin, Etc. |
| 100-16-04 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Miscellaneous Platework Details |
| 100-17-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Piping Diagram |
| 100-17-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Piping General Arrangement Plans |
| 100-17-03 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Piping General Arrangement Plans |
| 100-17-04 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Piping General Arrangement Sections |
| 100-18-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Instrumentation Diagram |
| 100-18-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Instrument Index<br>Sheets 1 through 6 |
| 100-19-01 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Single-Line Diagram |
| 100-19-02 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Power and Control Layout |
| 100-19-03 | 0 | Pilot Plant<br>Coal Deep Cleaning<br>Power and Control Layout |

| DRAWING NO. | REVISION | TITLE |
|---|---|---|
| 100-19-04 | 0 | Pilot Plant Coal Deep Cleaning Schematic and Control Block Diagram |

# APPENDIX 'A'

## ACTIVITIES FLOW CHART FOR THE PROJECT AND CORRESPONDENCE WITH THE SCIENTIFIC AUTHORITY

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Research and Technology
Recherche et Technologie

Canada Centre for Mineral and Energy Technology.
Centre canadien de la technologie des minéraux et de l'énergie.

Coal Research Laboratories
Laboratoires de Recherches sur le Charbon

P.O. Bag 1280
Devon, Alberta
TOC 1E0

Your file Votre référence

Our file Notre référence

February 3, 1986

RECEIVED
FEB 10 1986
Ans'd.

Mr. R.J. Davies, P.Eng
Project Manager
Kilborn Engineering (B.C.) Ltd.
1380 Bunard Street
Vancouver, B.C.
V6Z 2B7

Dear Jim,

**RE: DEEP CLEANING COAL PILOT PLANT DSS FILE NO. 03SQ.23440-4-9227**

As you are probably aware, we received the approval concerning the additional space from CMRC. I hope the work on this contract is progressing well. Attached please find the approved flowsheet with different options for the proposed deep cleaning pilot plant. Best regards.

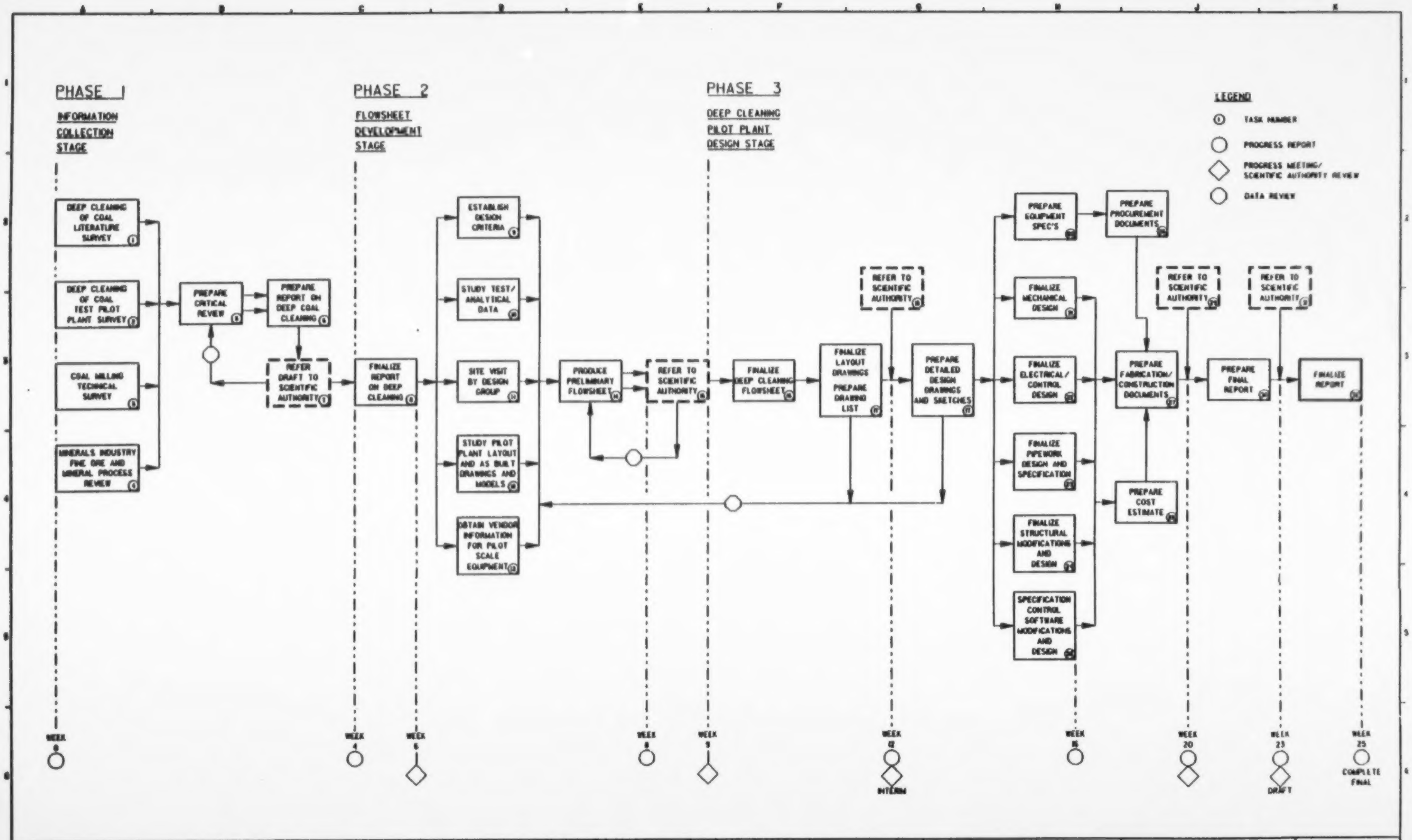
Yours truly,

Magdy W. Mikhail
Head Coal Preparation Section
Coal Research Laboratory

MWM/jr

Enclosure

Canada


PHASE 1
INFORMATION COLLECTION STAGE
PHASE 2
FLOWSHEET DEVELOPMENT STAGE
PHASE 3
DEEP CLEANING PILOT PLANT DESIGN STAGE
LEGEND
TASK NUMBER
PROGRESS REPORT
PROGRESS MEETING/ SCIENTIFIC AUTHORITY REVIEW
DATA REVIEW
DEEP CLEANING OF COAL LITERATURE SURVEY
DEEP CLEANING OF COAL TEST PILOT PLANT SURVEY
COAL MILLING TECHNICAL SURVEY
MINERALS INDUSTRY FINE ORE AND MINERAL PROCESS REVIEW
PREPARE CRITICAL REVIEW
PREPARE REPORT ON DEEP COAL CLEANING
REFER DRAFT TO SCIENTIFIC AUTHORITY
FINALIZE REPORT ON DEEP CLEANING
ESTABLISH DESIGN CRITERIA
STUDY TEST/ ANALYTICAL DATA
SITE VISIT BY DESIGN GROUP
STUDY PILOT PLANT LAYOUT AND AS BUILT DRAWINGS AND MODELS
OBTAIN VENDOR INFORMATION FOR PILOT SCALE EQUIPMENT
PRODUCE PRELIMINARY FLOWSHEET
REFER TO SCIENTIFIC AUTHORITY
FINALIZE DEEP CLEANING FLOWSHEET
FINALIZE LAYOUT DRAWINGS PREPARE DRAWING LIST
REFER TO SCIENTIFIC AUTHORITY
PREPARE DETAILED DESIGN DRAWINGS AND SKETCHES
PREPARE EQUIPMENT SPEC'S
PREPARE PROCUREMENT DOCUMENTS
FINALIZE MECHANICAL DESIGN
FINALIZE ELECTRICAL/ CONTROL DESIGN
FINALIZE PIPEWORK DESIGN AND SPECIFICATION
FINALIZE STRUCTURAL MODIFICATIONS AND DESIGN
SPECIFICATION CONTROL SOFTWARE MODIFICATIONS AND DESIGN
PREPARE FABRICATION/ CONSTRUCTION DOCUMENTS
PREPARE COST ESTIMATE
REFER TO SCIENTIFIC AUTHORITY
PREPARE FINAL REPORT
REFER TO SCIENTIFIC AUTHORITY
FINALIZE REPORT
WEEK 0
WEEK 4
WEEK 6
WEEK 8
WEEK 9
WEEK 12
INTERIM
WEEK 16
WEEK 20
WEEK 23
DRAFT
WEEK 25
COMPLETE FINAL

REFERENCE DRAWINGS

REVISIONS

REVISIONS

CLIENT: SUPPLY AND SERVICES, CANADA

LOCATION: COAL RESEARCH LAB., EMR., CANMET

KILBORN

TITLE

ACTIVITIES FLOWCHART FOR
DEVELOPMENT AND DESIGN
OF A PILOT PLANT FOR
COAL CLEANING PROCESSES

# APPENDIX 'B'

# EQUIPMENT LEDGER

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 10

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT.

| REVISIONS | | | | | | |
|---|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | PO Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT NO. |
|---|---|---|---|---|---|
| 10.10.01 | CRUSHER | | | | |
| | JEFFREY MINI-MILL | | JEFFREY - DRESSER | | |
| | 15 HP 1800 RPM MOTOR | | | | |
| | | | | | |
| | | | | | |
| 10.10.02 | BALL MILL | | | | |
| | SALA SRR 1800 x 3600 LG | | SALA | | |
| | (6' 0 x 12 long) | | | | |
| | 200 HP 1800 RPM MOTOR | | | | |
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FORM KE 230 REV 8

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 11

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT. SCREENS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
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| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EQR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF SPEC NO. MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 30.11.01 | HORIZONTAL VIBRATING SCREEN - | | | | |
| | 48" DIAMETER | | | | |
| | SWECO TYPE | | | | |

FORM KE 230 REV. 2.

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 15

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ No 7813 DIV. No 15

EQUIPMENT. FLOTATION CELLS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT No | DESCRIPTION | EOR No<br>REQ'N No | SUPPLIER | P.O. No | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 20.15.01 | PRIMARY FLOTATION CELLS - | | | | |
| | SALA, AS. 0.6.2 | | SALA | | |
| | c/w FEED BOX, DISCHARGE BOX | | | | |
| | AND FROTH LAUNDER | | | | |
| | (3 REQ'D 7.5 HP 1200 RPM MOTORS) | | | | |
| | | | | | |
| 20.15.02 | SECONDARY FLOTATION CELLS - | | | | |
| | SALA, AS 0.6.2 | | SALA | | |
| | c/w FEED BOX, DISCHARGE BOX | | | | |
| | AND FROTH LAUNDER | | | | |
| | (3 REQ'D 7.5 HP, 1200 RPM MOTORS) | | | | |
| | | | | | |
| | AIR BLOWER (SKID MOUNTED) | | SALA | | |
| | COMMON FOR BOTH PRIMARY & | | | | |
| | SECONDARY CELLS. | | | | |
| | 5 HP MOTOR | | | | |

FORM KE 230 REV 8.

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 17

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT. PLANT EQUIPMENT

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF. SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 10.17.01 | ROLL UP DOOR | | | | |
| | 8'-0" x 10'-0" high, 0.5 HP | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 10.17.02 | ROLL UP DOOR | | | | |
| | 8'-0" x 10'-0" high, 0.5 HP | | | | |

FORM KE 230 REV 8.

KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 20

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ No 7813

DIV. No 15

EQUIPMENT. HEATERS

| REVISIONS | | | | |
|---|---|---|---|---|
| 5 | | | 10 | |
| 4 | | | 9 | |
| 3 | | | 8 | |
| 2 | | | 7 | |
| 1 | | | 6 | |

| EQUIPMENT No | DESCRIPTION | EOR No<br>REQ'N No | SUPPLIER | P.O. No | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT NO. |
|---|---|---|---|---|---|
| 10.20.01 | DUCT HEATER - 20 KW | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 10.20.02 | UNIT HEATER 15 KW. | | | | |
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FORM KE 230 REV 2.

## KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 22

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

**EQUIPMENT.** CYCLONES

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF. SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 10.22.01 | CLASSIFYING CYCLONES | | CARPCO INC. | | |
| | C 516 MOZLEY 4 x 5" | | (WILFLEY CANADA) | | |
| | HP HYDROCYCLONES, c/w 22 mm | | | | |
| | VORTEX FINDER COMPLETE ASSY. | | | | |
| | | | | | |
| | | | | | |
| 20.22.03 | DEWATERING CYCLONES | | CARPCO INC. | | |
| | C109 MOZLEY 16 x 2" | | (WILFLEY CANADA) | | |
| | HYDROCYCLONE ASSY. | | | | |
| | COMPLETE | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 20.22.09 | THICKENING CYCLONES | | CARPCO INC. | | |
| | C109 MOZLEY 16 x 2" | | (WILFLEY CANADA) | | |
| | HYDROCYCLONE ASSY. | | | | |
| | COMPLETE | | | | |
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FORM KE 230 REV 2.

KILBORN **EQUIPMENT LEDGER**

EQUIPMENT GROUP 31

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. AGITATORS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF SPEC NO. MOTOR SHT NO. |
|---|---|---|---|---|---|
| 20.31.01 | AGITATOR FOR PRIMARY | | GALIGHER ASH | | |
| | CONDITIONER 20.82.10 | | | | |
| 20.31.02 | AGITATOR FOR SECONDARY | | GALIGHER ASH | | |
| | CONDITIONER - 20.82.11 | | | | |
| 20.31.03 | AGITATOR FOR CONDITIONER | | GALIGHER ASH | | |
| | 20.82.12 | | | | |

FORM KE 230 REV 8.

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 34

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. ELECTROSTATIC SEPARATOR

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT NO. |
|---|---|---|---|---|---|
| 50.34.01 | HIGH INTENSITY | | CARPCO | | |
| | ELECTROSTATIC SEPARATOR | | | | |

FORM KE 230 REV 2.

KILBORN **EQUIPMENT LEDGER**

EQUIPMENT GROUP 35

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

**EQUIPMENT.** MAGNETIC SEPARATOR

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | BOM Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 40.35.01 | HIGH GRADIENT | | CARPCO | | |
| | MAGNETIC SEPARATOR | | | | |
| 10.35.02 | MAGNETIC DRUM SEPARATOR | | SALA | | |
| | SALA 916 Ø x 600 LG | | | | |
| | 1 HP MOTOR | | | | |

FORM KE 230 REV 2

**KILBORN EQUIPMENT LEDGER**

EQUIPMENT GROUP 36

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

**EQUIPMENT.** CENTRIFUGE

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 20.36.01 | CLEAN COAL CENTRIFUGE | | BIRD MACHINE CO. | | |
| | BIRD ML 2500 SOLID BOWL | | OF CANADA | | |
| | CENTRIFUGE | | | | |
| | 18" Ø x 54" LONG | | | | |
| | MAIN DRIVE 50 HP, 1800 RPM | | | | |
| | LUBE PUMP 1 HP, 1800 RPM | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 30.36.02 | PELLETIZER - 6'-0" DIA | | TELEDYNE/READCO | | |
| | 5 HP MOTOR | | | | |
| | | | | | |
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FORM KE 230 REV. 2.

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 42

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

**EQUIPMENT.** MIXERS

| REVISIONS | | | | |
|---|---|---|---|---|
| 5 | | | 10 | |
| 4 | | | 9 | |
| 3 | | | 8 | |
| 2 | | | 7 | |
| 1 | | | 6 | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT NO. |
|---|---|---|---|---|---|
| 30.42.01 | HIGH SHEAR MIXER | | ROTEQUIP INC. | | |
| | 60 GAL. 30 HP MOTOR | | | | |
| | 22" 0 x 3'-0" HIGH INCL. | | | | |
| | TANK | | | | |
| 30.42.02 | LOW SHEAR MIXER | | ROTEQUIP INC. | | |
| | (500 GAL. TANK 30.82.15) | | | | |
| | 25 HP MOTOR | | | | |
| 30.42.03 | LOW SHEAR MIXER | | ROTEQUIP INC. | | |
| | 500 GAL TANK 30.82.16 | | | | |
| | 25 HP MOTOR | | | | |

FORM KE 230 REV 2

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 44

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. CRANES AND HOISTS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EQR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT NO. |
|---|---|---|---|---|---|
| 10.44.01 | JIB CRANE | | DEMAG OR SIMILAR | | |
| | 7.5m LIFT (25'-0") 2HP | | | | |

FORM KE 230 REV 2.

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 62

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT. FANS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EDR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF. SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 10.62.01 | MILL AREA EXHAUST FAN | | | | |
| | 7 1/2 HP | | | | |
| 10.62.02 | MCC ROOM PRESSURIZING FAN | | | | |
| | 1 1/2 HP | | | | |
| 10.62.03 | REAGENT FUME EXHAUST FAN | | | | |
| | 3 HP | | | | |

FORM KE 230 REV 2

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 63

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON 2

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. SLURRY PUMPS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EDR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF SPEC NO. MOTOR SHT NO. |
|---|---|---|---|---|---|
| 10.63.01 | BALL MILL REED PUMP, | | SALA | | |
| | & PUMPBOX - VERTICAL - | | | | |
| | SALA, SPV-232-2, TANK | | | | |
| | 0.7 $M^3$ 3 HP MOTOR | | | | |
| | | | | | |
| 10.63.02 | BALL MILL DISCHARGE PUMP | | SALA | | |
| | & PUMPBOX - VERTICAL | | | | |
| | SALA, SPV-263-3, TANK | | | | |
| | 1.3 $m^3$ 20 HP MOTOR | | | | |
| | | | | | |
| 20.63.03 | DEWATERING CYCLONE FEED | | SALA | | |
| | PUMP, & PUMPBOX - VERTICAL | | | | |
| | SALA, SPV 263-3, TANK | | | | |
| | 1.3 $m^3$ 25 HP MOTOR | | | | |
| | | | | | |
| 20.63.04 | FEED PUMP & PUMPBOX, | | SALA | | |
| | VERTICAL - SALA, SPV 232-2 | | | | |
| | TANK 1.3 $m^3$ 5 HP MOTOR | | | | |
| | | | | | |
| | | | | | |
| 20.63.05 | NOT REQUIRED | | | | |
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FORM KE 230 REV 8

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 03

CLIENT. SUPPLY & SERVICES CANADA

SHEET 2 CONT'D ON 3

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. SLURRY PUMPS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF. SPEC NO. MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 20.63.06 | THICKENING CYCLONE FEED PUMP | | SALA | | |
| | & PUMPBOX - VERTICAL - SALA | | | | |
| | SPV 304-4 TANK 1.3 $m^3$ | | | | |
| | 50 HP MOTOR | | | | |
| | | | | | |
| | | | | | |
| 30.63.07 | NOT USED | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 40.63.08 | H.G.M.S. PRODUCT PUMP & PUMPBOX - | | SALA | | |
| | VERTICAL-SALA, SPV-232-2 | | | | |
| | 3 HP MOTOR | | | | |
| | | | | | |
| | | | | | |
| 20.63.09 | CENTRIFUGE FEED PUMP & PUMPBOX - | | SALA | | |
| | VERTICAL - SALA - SPV 232-2 | | | | |
| | 3 HP MOTOR | | | | |
| | | | | | |
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FORM KE 230 REV. 2.

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 63

CLIENT. SUPPLY & SERVICES CANADA

SHEET 3 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT. METERING PUMPS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EQR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF SPEC NO. MOTOR SHT NO. |
|---|---|---|---|---|---|
| 20.63.11 | REAGENT METERING PUMP AUTO, | | BLACK & BAIRD | | |
| | WITH DUPLEX HEAD | | | | |
| | BIF MODEL 1212.15.9620 | | | | |
| 20.63.12 | REAGENT METERING PUMP | | | | |
| | AUTO, SRC, CONT & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |
| 20.63.13 | REAGENT METERING PUMP | | | | |
| | AUTO, SRC. CONT. & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |
| 20.63.14 | REAGENT METERING PUMP MANUAL | | | | |
| | BIF MODEL 1211.15.9222 | | | | |
| 20.63.15 | REAGENT METERING PUMP | | | | |
| | AUTO, WITH DUPLEX HEAD<br>BIF MODEL 1212.15.9620 | | | | |
| 20.63.16 | REAGENT METERING PUMP | | | | |
| | AUTO, SRC. CONT & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |
| 20.63.17 | REAGENT METERING PUMP AUTO | | | | |
| | SRC. CONT. & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |
| 20.63.18 | REAGENT METERING PUMP MANUAL | | | | |
| | BIF MODEL 1211.15.9222 | | | | |
| 10.63.19 | BALL MILL<br>REAGENT METERING PUMP | | | | |
| | AUTO, SRC, CONT. & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |
| 10.63.20 | SPARE | | | | |
| | | | | | |
| 30.63.21 | OIL METERING PUMP - AUTO, SRC.<br>CONT. & DC MOTOR - BIF MODEL | | | | |
| | BIF MODEL 1211.15.9220 | | | | |
| 20.63.22 | STABILIZER METERING PUMP | | | | |
| | AUTO - SRC. CONT. & DC MOTOR<br>BIF MODEL 1211.15.9220 | | | | |

130 REV 8.

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 82

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON 2

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. TANKS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 20.82.10 | PRIMARY CONDITIONER TANK, | | GALIGHER ASH | | |
| &<br>20.31.01 | c/w AGITATOR | | | | |
| | GALIGHER ASH GHO-40-0 | | | | |
| | 75 HP MOTOR 1750 RPM | | | | |
| | 1.2 m Ø TANK x 1.2 m HIGH | | | | |
| | | | | | |
| | | | | | |
| 20.82.11 | SECONDARY CONDITIONER TANK | | GALIGHER ASH | | |
| &<br>20.31.02 | c/w AGITATOR | | | | |
| | GALIGHER ASH GHO.40.0 | | | | |
| | 75 HP MOTOR 1750 RPM | | | | |
| | 1.2 m Ø TANK x 1.2 m HIGH | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| 20.82.12 | CONDITIONER (COAL WATER FUEL) | | | | |
| &<br>20.31.03 | c/w AGITATOR | | | | |
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FORM KE 230 REV 8

# KILBORN EQUIPMENT LEDGER

EQUIPMENT GROUP 82

CLIENT. SUPPLY & SERVICES CANADA

SHEET 2 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813 DIV. Nº 15

EQUIPMENT. TANKS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EQR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF. SPEC. NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 20.82.13 | REAGENT TANK & MIXER | | BLACK & BAIRD | | |
| | 1/4 HP MOTOR | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 20.82.14 | REAGENT TANK & MIXER | | BLACK & BAIRD | | |
| | 1/4 HP MOTOR | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 30.82.15 | LOW SHEAR MIXER TANKS | | | | |
| | 6'-0" Ø x 6'-0" HIGH | | | | |
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FORM KE 230 REV. 8.

**KILBORN** EQUIPMENT LEDGER

EQUIPMENT GROUP 89

CLIENT. SUPPLY & SERVICES CANADA

SHEET 1 CONT'D ON 2

PROJECT DEVON - PILOT PLANT

PROJ Nº 7813

DIV. Nº 15

EQUIPMENT. MISC. METALS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EGR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO. PERF. SPEC NO. MOTOR SHT NO. |
|---|---|---|---|---|---|
| | | | | | |
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| | | | | | |
| 20.89.02 | O/FLOW BOX | | | | |
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| 20.89.03 | SPLITTER BOX | | | | |
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| 20.89.04 | O/FLOW BOX | | | | |
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| 20.89.05 | SPLITTER BOX | | | | |
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FORM KE 230 REV 2.

**KILBORN EQUIPMENT LEDGER**

EQUIPMENT GROUP 89

CLIENT. SUPPLY & SERVICES CANADA

SHEET 2 CONT'D ON

PROJECT DEVON - PILOT PLANT

PROJ Nº 7313

DIV. Nº 15

**EQUIPMENT.** MISC. METALS

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| 5 | | | 10 | | |
| 4 | | | 9 | | |
| 3 | | | 8 | | |
| 2 | | | 7 | | |
| 1 | | | 6 | | |

| EQUIPMENT Nº | DESCRIPTION | EOR Nº<br>REQ'N Nº | SUPPLIER | P.O. Nº | BOM NO.<br>PERF. SPEC NO.<br>MOTOR SHT. NO. |
|---|---|---|---|---|---|
| 10.89.06 | ALTERNATE FEED BIN | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 20.89.07 | COAL/WATER FUEL BIN | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| 20.89.08 | CENTRIFUGE FEED BOX | | | | |
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FORM KE 230 REV 2.

# APPENDIX 'C'

## PERFORMANCE SPECIFICATIONS FOR MAJOR EQUIPMENT

**KILBORN**

**PERFORMANCE SPECIFICATION No.** 7813-15-01

**CLIENT** EMR-CANMET **PROJ. No.** 7813 **Sheet No.** 1 **of** 3
**PROJECT** DEEP COAL CLEANING PILOT PLANT **DIV. No.** 15 **BY** G.W. LAMAN
**AREA**
**SUBJECT** BALL MILL

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
|  |  | — | — |

**EQUIP/TAG Nos**
**DATE** NOVEMBER 29, 1985
**REF. DWG. No.**
**REV. DATES** MARCH 17, 1986

1.0 SCOPE OF WORK

1.1 The Bidder shall submit a preliminary proposal for the following equipment in accordance with the information and data specified:

| Item | Quantity | Description |
|---|---|---|
| 1 | One (1) | Wet overflow type ball mill, complete with spout feeder, constant speed drive assembly base, coupling and all necessary accessories<br>so that the complete mill will be fully operational. Equipment to be sized by Bidder. |

2.0 WORK NOT INCLUDED

2.1 Electric motors and motor controls unless an integral part of the equipment.

2.2 Electric wiring and conduits.

2.3 Interconnecting pipework, external to and not forming an integral part of mills and auxiliary systems.

2.4 Installation labour.

2.5 Foundation and foundation bolts.

3.0 OPERATION AND DUTY

3.1 The ball mill will be used to grind the clean coal from an existing pilot plant.

3.2 The equipment will be installed in a heated building.

3.3 The pilot plant will be treating various types of coal, and consequently the feed material to the ball mill varies in rank from sub-bituminous to anthracite.

3.4 The ball mill will be operated in closed circuit with hydrocyclone classifiers designed to operate of a $d_{50}$ cutpoint of between 20 and 25 micron meters.

3.5 The Bidder shall size the ball mill for the following conditions:

## 4.0 OPERATING CONDITIONS

### 4.1 Feed

Material - Clean coal
Bulk Density - 800 kg/$m^3$
Size Fraction - 2 mm x 0
Rate - 2 tonne/hour

### 4.2 Product

Discharge - 95% passing 45 microns or finer.

4.3 Please specify value or range of Bond (grindability) Work Index used to determine the size of the mill offered in the proposal, or any other assumptions made whichinfluence mill selection.

## 5.0 MATERIALS OF CONSTRUCTION

5.1 Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

6.1 Painting shall be manufacturer's standard forthe duty specified.

## 7.0 ASSEMBLY

7.1 All Components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match-marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purchase order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starters and controls unless an integral part of the equipment.

## 9.0 ELECTRICAL REQUIREMENTS

9.1 All standard motors shall be supplied by others. The Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, rpm, and frame and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the Bidder or bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement, complete with anchor bolt sizes and locations.

10.3 Vendor shall provide a recommended spare parts list for one year of operation.

## KILBORN ENGINEERING (B.C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-01

## BALL MILL

## EQUIPMENT INFORMATION SUMMARY

The following technical information is to be supplied by the Bidder;

Bidder Name:

Quotation Reference No.:

Manufacturer:

Model No.:

Equipment Size:

Feed Inlet Opening Size:

Discharge Opening Size:

Net Weight of Equipment:

Recommended Motor: HP/RPM:

Ball Charge Requirements:

### SPARE PARTS

List of recommended spare parts with current prices to be maintained in stock for servicing all items in the purchase requisitions for one (1) year for the duty and service specified.

**KILBORN** **PERFORMANCE SPECIFICATION No.** 7813-15-02

**CLIENT** EMR - CANMET **PROJ. No.** 7813 **Sheet No.** 1 **of** 3
**PROJECT** DEEP COAL CLEANING PILOT PLANT **DIV. No.** 15 **BY** G. W. LAMAN
**AREA** PILOT PLANT
**SUBJECT** CLEAN COAL CRUSHER
**EQUIP./TAG Nos**
**REF. DWG. No.**

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

**DATE** DECEMBER 9, 1985
**REV. DATES** MARCH 17/86

## 1.0 SCOPE OF WORK

Design, manufacture and supply one (1) Coal Crusher complete with all necessary accessories and controls, herein referred to collectively as the equipment.

### 1.1 SERVICE

The Crusher shall reduce the larger size damp clean coal (10 mm upper size ) to smaller granular particles (2 mm upper size).

## 2.0 DESCRIPTION OF EQUIPMENT

2.1 The Crusher may be a hammer mill, impact type which utilizes individually removable cast manganese grate bars. It may also be a single roll crusher type.

The Vendor shall determine the equipment size required and provide backup details for his selection.

The equipment shall include the following features:

(a) The main frame shall be of sectional design, fabricated steel, bolted construction with dust tight fit joints.

(b) Quick opening doors shall be conveniently located for easy and fast access to internal parts.

(c) Easily replaceable breaker plate and screen bars.

(d) All drive guards shall comply with OSHA Standards.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for handling coal, and be supplied as a complete and operable unit with all necessary auxiliaries.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

### 4.1 Feed

| | | |
|---|---|---|
| Material | - | Clean coal |
| Bulk Density | - | 800 kg/m³ |
| Size Fraction | - | 10 mm x 0 |
| Rate | - | 2 tonne/hour |
| Surface Moisture | - | 15% by weight |

### 4.2 Product

| | | |
|---|---|---|
| Discharge | - | 95% passing 2 mm or finer. |

## 5.0 MATERIALS OF CONSTRUCTION

5.1 Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

6.1 Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All Components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match-marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purchase order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starters and controls unless an integral part of the equipment.

## 9.0 ELECTRICAL REQUIREMENTS

9.1 All standard motors shall be supplied by others. The Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, rpm, and frame and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the bidder or bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement, complete with anchor bolt sizes and locations.

10.3 Vendor shall provide a recommended spare parts list for one year of operation.

## KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-02

## CLEAN COAL CRUSHER

### EQUIPMENT INFORMATION SUMMARY

The following technical information is to be supplied by the Bidder:

Bidder Name:

Quotation Reference No.:

Manufacturer:

Model No.:

Equipment Size:

Feed Inlet Opening Size:

Discharge Opening Size:

Net Weight of Equipment:

Recommended Motor: HP/RPM:

### SPARE PARTS

List of recommended spare parts with current prices to be maintained in stock for servicing all items in the purchase requisitions for one (1) year for the duty and service specified.

**KILBORN** **PERFORMANCE SPECIFICATION No.** 7813-15-03

CLIENT EMR - CANMET PROJ. No. 7813 Sheet No. 1 of 4
PROJECT DEEP COAL CLEANING PILOT PLANT DIV. No. 15 BY G. W. LAMAN
AREA PILOT PLANT
SUBJECT CYCLONES

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | — | — | |

EQUIP/TAG Nos SEE BELOW DATE DECEMBER 17, 1985
REF. DWG. No. REV. DATES MARCH 17, 1986

## 1.0 SCOPE OF WORK

This Specification covers the design, fabrication, supply and delivery of eight (8) Classifying Cyclones, complete with all necessary accessories and controls, herein referred to collectively as the equipment.

## 1.1 SERVICE

| Item | Description |
|---|---|
| 1 | Classifying Cyclones - to classify ball mill discharge to a $d_{50}$ separation required at about 25 micron |
| 2 | Dewatering Cyclones - to dewater classifying cyclone overflow to a $d_{50}$ separation required at about 5 micron |
| 3 | Thickening Cyclones - to thicken flotation cell tailing to a $d_{50}$ separation required at about 5 micron |

## 2.0 DESCRIPTION OF EQUIPMENT

2.1 Item 1 - Equipment Nos. 10-22-01 and 10-22-02.

The equipment shall be two (2) Classifying Cyclones with a diameter of 150 millimetres or equivalent, and an included cone angle of not more than 20°. The Vendor shall then verify and indicate if the suggested cyclone size and quantities are in agreement with their own selection.

2.2 Item 2 - Equipment Nos. 20-22-03 to 20-22-08 inclusive.

The equipment shall be six (6) Dewatering Cyclones with a diameter of 75 millimetres or equivalent, and an included cone angle of not more than 20°. The Vendor shall then verify and indicate if the suggested cyclone size and quantities are in agreement with their own selection.

### 2.3 Item 3

The equipment shall be six (6) Thickening Cyclones with a diameter of 75 millimetres or equivalent, and an included cone angle of not more than 20°. The Vendor shall then verify and indicate if the suggested cyclone size and quantities are in agreement with their own selection.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for handling coal and supplied as complete and operable units with all necessary auxiliaries.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

4.1 The feed rate to the 'classifying' cyclones is per cyclone cluster.

| | Item 1 | Item 2 | Item 3 |
|---|---|---|---|
| Throughput: | | | |
| Volume m³/h | 50.3 | 40.3 | 37 |
| Feed Solids % by Weight (Max.) | 15 | 5 | 10 |
| Top Size - (a) | 0.3 mm | 0.15 mm | 0.15 mm |
| (b) | 0.15 mm | 0.08 mm | - |
| *Desired Cutpoint - (a) | 75 micron | 10 micron | 10 micron |
| (b) | 45 micron | - | - |

*Defined as 95 percent classified size for solids of 1.5 s.g.

The Vendor shall indicate how the different cutpoints for Item 1 can be obtained.

## 5.0 MATERIALS OF CONSTRUCTION

5.1 Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

6.1 Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match-marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purcahse order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starters and controls unless an integral part of the equipment.

## 9.0 ELECTRICAL REQUIREMENTS

9.1 All standard motors shall be supplied by others. The Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, rpm, and frame and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the bidder or bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement, complete with anchor bolt sizes and locations.

10.3 Vendor shall provide a recommended spare parts list for one year of operation.

KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-03

## CYCLONES

## EQUIPMENT INFORMATION SUMMARY

Bidder: ____________________

Manufacturer: ____________________

Point of Manufacture: ____________________

The following information will be required for Items 1, 2 and 3:

Equipment No.: ____________________

Type of Cyclone: ____________________

Proposed Model: ____________________

Service: ____________________

Cyclone Diameter: ____________________

Cone Angle: ____________________

Feed Inlet Diameter (I.D.): ____________________

Feed Inlet Flange or Coupling Size: ____________________

Overflow Diameter (I.D.): ____________________

Overflow Flange or Coupling Size: ____________________

Apex Size: ____________________

Material of Construction: ____________________

____________________

____________________

Weight of Assembled Classifying Cyclones:

Heaviest Piece: ____________________

Largest Piece: ____________________

PERFORMANCE SPECIFICATION NO. 7813-15-03
EQUIPMENT INFORMATION SUMMARY

Exception to Specification:

Alternatives:

KILBORN **PERFORMANCE SPECIFICATION No.** 7813-15-04

| | | | |
|---|---|---|---|
| **CLIENT** EMR - CANMET | **PROJ. No.** 7813 | **Sheet No.** 1 **of** 3 | |
| **PROJECT** DEEP COAL CLEANING PILOT PLANT | **DIV. No.** 15 | **BY** G. W. LAMAN | |
| **AREA** PILOT PLANT | | **File No.** | **Area** / **Sect.** — / **Spec.** — |
| **SUBJECT** FROTH FLOTATION CELL | | | |
| **EQUIP/TAG No.s** | | **DATE** DECEMBER 17, 1985 | |
| **REF. DWG. No.** | | **REV. DATES** MARCH 17, 1986 | |

## 1.0 SCOPE OF WORK

Design, manufacture and supply two (2) banks of flotation cells (ie. primary and secondary) complete with all necessary accessories and controls, herein referred to collectively as the equipment.

## 1.1 SERVICE

The primary bank will process pre-conditioned coal slurry with a top size of 95 percent passing 75 micron. The secondary bank will process after conditioning the froth or the tailing of the primary bank.

## 2.0 DESCRIPTION OF EQUIPMENT

2.1 The primary circuit shall be a bank of six (6) flotation cells. The approximate size of each cell shall be 0.6 $m^3$ (21 $feet^3$).

The secondary circuit shall be a bank of six (6) flotation cells. The approximate size of each cell shall be 0.6 $m^3$ (21 $feet^3$).

The Vendor shall verify and indicate if the suggested size is in agreement with this selection.

The equipment supplied shall include the following features:

- One feed box and one discharge box. Discharge box complete with automatic level control dart valve.
- One supply air blower and header complete with valves to control air supply to each cell.
- Paddles to remove froth.
- The bank shall be of the cell to cell type, each cell provided with an adjustable weir and individual sand gate.
- The rotor and stator mechanisms to be resistant to MIBC, kerosene and abrasion.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for handling coal, and be supplied as a complete and operable unit with all necessary auxiliaries.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

### 4.1 Primary Bank

| | |
|---|---|
| Feed to Bank: | Coal slurry 100 x 0 micron |
| Required Retention Time: | 4 minutes |
| Maximum Volume Pulp: | 40.4 $m^3/h$ |
| Maximum Percent Solids: | 5% by weight |
| Maximum Solids: | 2.0 t/h |
| S.G. Solids: | 1.4 |

### 4.2 Secondary Bank

| | |
|---|---|
| Feed to Bank: | Coal slurry 100 x 0 micron |
| Required Retention Time: | 4 minutes |
| Maximum Volume Pulp: | 40.4 $m^3/h$ |
| Maximum Percent Solids: | 5% by weight |
| Maximum Solids: | 2.0 t/h |
| S.G. Solids: | 1.4 |

## 5.0 MATERIALS OF CONSTRUCTION

5.1 Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

6.1 Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match-marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purcahse order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starters and controls unless an integral part of the equipment.

## 9.0 ELECTRICAL REQUIREMENTS

9.1 All standard motors shall be supplied by others. The Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, rpm, and frame and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the bidder or bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement, complete with anchor bolt sizes and locations.

10.3 Vendor shall provide a recommended spare parts list for one year of operation.

## KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-04

## FROTH FLOTATION CELL

## EQUIPMENT INFORMATION SUMMARY

Technical information to be supplied by bidder:

Bidder's Name: ____________________

Quotation Reference No.: ____________________

Manufacturer: ____________________

Model No.: ____________________

Cell Volume: ____________________ m³ (__________ ft³)

Blower Capacity: ____________________ m³/sec (__________ cfm)

Feed Flange Size: ____________________

Tailing Flange Size: ____________________

Net Weight of Equipment: ____________________

Recommended Motors:

Agitator Drive Motor: Hp/rpm: ____________________

Number of Agitator Drives: ____________________

Froth Paddle Drive Motor: Hp/rpm: ____________________

Number of Paddle Drive Motors: ____________________

Blower Drive Motor: Hp/rpm: ____________________

### SPARE PARTS

List of recommended spare parts with current prices to be maintained in stock for servicing all items in the purchase requisitions for one year for the duty and service specified.

PERFORMANCE SPECIFICATION NO. 7813-15-04
EQUIPMENT INFORMATION SUMMARY

Principal Manufacturers or Suppliers of Major Components:

Exceptions to Specifications:

**KILBORN** **PERFORMANCE SPECIFICATION No.** 7813-15-05

CLIENT EMR-CANMET PROJ. No. 7813 Sheet No. 1 of 3
PROJECT DEEP COAL CLEANING PILOT PLANT DIV. No. 15 BY G.W. LAMAN
AREA PILOT PLANT
SUBJECT CONDITIONER

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

EQUIP/TAG Nos AS NOTED BELOW DATE DECEMBER 31, 1985
REF. DWG. No. N/A REV. DATES MARCH 17, 1986

## 1.0 SCOPE OF WORK

This specification covers the design, fabrication, supply and delivery of three (3) conditioners, complete with tanks and all necessary accessories and controls, herein referred to collectively as 'the equipment'.

## 1.1 SERVICE

| Item | Description. |
|---|---|
| 1 | Flotation conditioner agitator, for uniform suspension of a coal slurry in a 1200 mm diameter by 1200 mm, top overflow tank. (Two required.) |
| 2 | Coal Water fuel conditioner agitator, for uniform suspension of a Coal-Water mixture in a 500 mm diameter by 500 mm top overflow tank. (One required.) |

## 2.0 DESCRIPTION OF EQUIPMENT

2.1 Item 1.
Equipment Nos. 20-31-01 and -02.
Two (2) only - Top entering, bridge mounted, mechanical conditioners, each complete with tank, mounting bridge, impeller, shaft, reducer and drive.

Item 2.
Equipment No. 20-31-03.
One (1) only - Top entering, top mounted mechanical conditioner complete with tank, impeller shaft, reducer and drive.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for handling coal and supplied as complete and operable units with all necessary auxiliaries.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

### 4.1 CONDITIONERS

| | Item 1 | Item 2 |
|---|---|---|
| Mixing duty | Uniform suspension | Uniform suspension |
| Tank discharge | Top overflow | Bottom |
| Volume $m^3/h$ | 40.4 | 4 |
| Slurry Relative Density | 1.01 | 1.17 |
| Percent solids by weight | 5 | 50 |
| Solids Relative Density | 1.4 | 1.4 |
| Particle size - $d_{95}$, micron | 75 | 75 |

## 5.0 MATERIALS OF CONSTRUCTION

5.1 Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

6.1 Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match-marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purchase order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starters and controls unless an integral part of the equipment.

## 9.0 ELECTRICAL REQUIREMENTS

9.1 All standard motors shall be supplied by others. The Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the power, rpm, and frame and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the bidder or bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement, complete with anchor bolt sizes and locations.

10.3 Vendor shall provide a recommended spare parts list for one year of operation.

KILBORN LIMITED

# PERFORMANCE SPECIFICATION NO. 7813-15-05

## CONDITIONER

## EQUIPMENT INFORMATION SUMMARY

The following information is to be supplied for each conditioner:

Service: ______

Manufacturer: ______

Model: ______

Quotation Reference No.: ______

Equipment No.(s): ______

Type of Conditioner: ______

Impeller:

Removable: ______ Protecting Covering: ______

Lip Speed: ______ Diameter ______

Distance, from bottom of tank: ______

Impeller Blade:

Type: ______ Number: ______ Material: ______

Attachment: ______

Protective Covering: ______

Shaft Coupling: Type: ______

Shaft Seal: Required: ______ Type: ______

Shaft: Length: ______ Diameter: ______

Material: ______ rpm: ______

Height required for shaft and impeller removal: ______

Tank Baffles Recommended: Quantity: ______ Width: ______

# CONDITIONER

SHEET 2 OF 2

## PERFORMANCE SPECIFICATION NO. 7813-15-05

## EQUIPMENT INFORMATION SUMMARY

Draught-Tube: Length: N/A Diameter: ________

Material: N/A

Weight: N/A

Support Method: N/A

Slurry Velocity: N/A

Annulus Slurry Velocity: N/A

Motor: Type: ________ kw (hp): ________

rpm: ________ Included: ________

Starting Torque: ________

Common Motor Reducer Bedplate Included: ________

Reducer: Manufacturer: ________

Model No.: ________ Size: ________

Reduction Ratio: ________ Service Factor: ________

Coupling Guards: Type: ________ Included: ________

Painting: Spec.: ________ Colour: ________

Lubrication: ________

Weight of Conditioner when assembled: ________

**KILBORN**

**PERFORMANCE SPECIFICATION No.** 7813-15-06

CLIENT EMR-CANMET PROJ. No. 7813 Sheet No. 1 of 2
PROJECT DEEP COAL CLEANING PILOT PLANT DIV. No. 15 BY G.W. LAMAN
AREA PILOT PLANT
SUBJECT SOLID BOWL CENTRIFUGE
EQUIP/TAG No.s
REF. DWG. No.
DATE DECEMBER 31, 1985
REV. DATES MARCH 17, 1986

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

## 1.0 SCOPE OF WORK

Design, manufacture and supply one (1) Solid Bowl Centrifuge complete with all necessary accessories and controls, herein referred to collectively as 'the equipment'.

### 1.1 SERVICE

The Solid Bowl Centrifuge will reduce the surface moisture of the minus 45 micron clean coal. .

## 2.0 DESCRIPTION OF EQUIPMENT

2.1 The centrifuge shall be a Solid Bowl type. The approximate bowl size is 457 mm (18") diameter by 1372 mm (54") long. The vendor shall verify and indicate if the suggested size is in agreement with his selection.

2.2 The equipment supplied shall include the following features:

(1) Solid bowl enclosed in a carbon steel case.

(2) A scrolL flight inside the bowl to remove the solids.

(3) The equipment shall be arranged for floor mounting complete with suspension designed to minimize dynamic loading.

(4) The equipment shall be furnished with a complete lubrication system.

(5) The equipment shall have replaceable liners on all wetted surfaces.

(6) The equipment shall be equipped with overload protection and automatic torque controls.

(7) Electrical enclosures of motor(s) and other electrical components supplied with the equipment shall be Class II, Division 2, Group F.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for the operating conditions specified.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

### 4.1 FEED

| | | | |
|---|---|---|---|
| Size fraction | - | $D_{95}$* | 45 micron |
| | - | $D_{50}$** | 25 micron |

Maximum feed rate:

| | |
|---|---|
| Solids - maximum | 2 tonne/hour |
| Water - maximum | 3 $m^3$/hour |
| S.G. of solids | 1.4 |

* 95% passing
** 50% passing

### 4.2 PRODUCT

| | |
|---|---|
| Surface Moisture (maximum) | 40 percent |
| Recovery Solids (minimum) | 98 percent |

4.3 It should be noted that the emphasis should be placed upon maximizing solids recovery at the expense of cake moisture content. The desirable product is of a mud consistancy. NO polymer flocculation agents or other centrifugation aid should be used as this will interfere with subsequent slurry stabilizing agent performance.

## KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-06

## SOLID BOWL CENTRIFUGE

## EQUIPMENT INFORMATION SUMMARY

Technical information to be supplied by bidder:

1. Bidder Name ______________________________
2. Quotation Reference No. ______________________________
3. Manufacturer ______________________________
4. Model No. ______________________________
5. Bowl dimensions ______________________________
6. Feed Flange Diameter ______________________________
7. Bowl Lining Material ______________________________
8. Scrol Lining Material ______________________________
9. Casing Lining Material ______________________________
10. Net Weight of Equipment ______________________________
11. Main Drive Motor, HP/rpm ______________________________
12. Lube Pump Motor, HP/rpm ______________________________
13. Lube Pump Motor Included: Yes ( ); No ( )

### Spare Parts

List of recommended spare parts with current prices to be maintained in stock for servicing all items in the purchase requisitions for one year for the duty and service specified.

## PERFORMANCE SPECIFICATION NO. 7813-15-06

## SOLID BOWL CENTRIFUGE

## EQUIPMENT INFORMATION SUMMARY

Principal Manufacturers of Suppliers of Major Components:

Exceptions to Specifications:

**KILBORN**

**PERFORMANCE SPECIFICATION No.** 7813-15-07

**CLIENT** EMR - CANMET **PROJ. No.** 7813 Sheet No. 1 of 4
**PROJECT** DEEP COAL CLEANING PILOT PLANT **DIV. No.** 15 **BY** G.W. LAMAN
**AREA** PILOT PLANT
**SUBJECT** SLURRY PUMPS
**EQUIP/TAG No.s**
**REF. DWG. No.**

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

**DATE** JANUARY 2, 1986
**REV. DATES** MARCH 17, 1986

1.0 SCOPE OF WORK

Design, manufacture and supply of six (6) slurry pumps complete with all necessary accessories and controls, herein referred to collectively as the equipment.

1.1 SERVICE

The equipment shall pump slurries as specified in the attached pump data sheets 1 and 2.

| Item | Quantity No. | Equipment No. | Description | Product Pumped |
|---|---|---|---|---|
| 1 | 1 | 10.63.01 | Ball mill feed pump | Coal slurry |
| 2 | 1 | 10.63.02 | Ball mill discharge pump | Coal slurry |
| 3 | 1 | 20.63.03 | Dewatering cyclone feed pump | Coal slurry |
| 4 | 1 | 20.63.04 | Primary conditioner feed pump | Coal slurry |
| 5 | 1 | 20.63.05 | H.G.M.S. feed pump | Coal slurry |
| 6 | 1 | 20.63.06 | Thickening cyclone feed pump | Flotation tailing |

It should be noted that the equipment will be installed in a test plant which is operated at less than 500 hours per year. Consideration should therefore be given to this fact when equipment is offered.

2.0 DESCRIPTION OF EQUIPMENT

Equipment Numbers - See pump data sheet 1 and 2.

Six (6) only vertical centrifugal slurry pumps. Each pump will be supplied complete with centrifugal seal and adjustable motor base.

V-belt drive and guard in accordance with National and provincial safety regulations.

## 3.0 DUTY

3.1 The equipment supplied shall be of heavy duty design suitable for handling coal slurries and supplied as complete and operable units with all necessary auxiliaries.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

See pump data sheet 1 and 2 for details on each pump installation.

## 4.1 DETAIL DESIGN REQUIREMENTS

(a) Pumps are to be sized to deliver design flow rate at the design total dynamic head.

(b) Drives will preferably be designed for 1800 rpm TEFC motors, mounted on overhead adjustable base. Bidder to identify any pumps where motor size inhibits overhead mounting.

(c) Suction and discharge flanges are to meet ANSI standards for flat faced flanges, otherwise suitable companion flanges are to be quoted as an extra, as unit price for each pump size.

(d) All exposed rotating parts are to be provided with totally enclosed guards made to OSHA standards and all applicable Federal and Provincial Regulations in British Columbia. Design guards for lubrication of enclosed moving parts and full movement of take up adjustment without dismantling guard; design for easy removal of guard using normal maintenance tools and for heavy duty service.

(e) If bidder wishes to propose items which deviate from this specification, bid as alternative or note deviations in the proposal.

## 5.0 MATERIALS OF CONSTRUCTION

Casing - Cast iron with replaceable, Ni-hard liners.

Impeller - Ni-hard, provided with external adjustment for running clearance.

Expeller - Ni-hard.

Shaft Seal - Centrifugal seal, gland fitted for grease lubrication of packing, with adjustable gland follower. Water sealant glands will not be accepted.

Shaft Sleeve - Manufacturer's standard for the duty specified.

## 6.0 PAINTING

Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purchase order number, vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electric motors, starter, external wiring, etc. (unless an integral part of the equipment).

## 9.0 ELECTRICAL REQUIREMENTS

All standard electric motors shall be supplied by others unless stated otherwise in the specification. Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, rpm, frame size and starting torque requirement. The motor will be sent to the Vendor for mounting, and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per the attached Equipment Information Summary, which must be completed by the bidder or the bid package will not be considered complete.

11.2 Proposal package shall include preliminary drawings indicating mounting arrangement complete with anchor bolt sizes and locations.

11.3 Vendor shall supply a spare parts list.

SHEET 1 OF 1

## KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-07

## SLURRY PUMPS

## EQUIPMENT INFORMATION SUMMARY

1. Equipment No. ____________________
2. Pump Manufacturer ____________________
3. Model No. ____________________
4. Size ____________________
5. Direction of Rotation Viewed from Driven End ____________________
6. Shaft Seal: Centrifugal ( ); Mechanical ( )
7. Bearing Lubrication: Oil ( ); Grease ( )
8. Paint Specification ____________ Colour ____________
9. Drive Connection: Direct Coupled ( ) V-Belt ( )
10. Couplings: Type ________ Manufacturer ________ Included ________
11. Reducer: Type ________ Manufacturer ________ Included ________
12. Drive Guards: Tupe ________ Manufacturer ________ Included ________
13. Sheaves: Type ________ Manufacturer ________ Included ________
14. V-Belts: Type ________ Manufacturer ________ Included ________
15. Motor: HP ________ RPM ________ Frame Size ________
16. Motor Slide Rails: Required ( ); Not Required ( ); Included ________
17. Motor Location: Overhead ( ); Side Mounted ( )
18. Baseplate: Included ____________________
19. Materials of Construction:
    - Casing ____________________
    - Impeller ____________________
    - Shaft ____________________
    - Shaft Sleeves ____________________
    - Liners ____________________

KILBORN

PERFORMANCE SPECIFICATION No. ______

CLIENT EMR - CANMET
PROJ. No. 7813
Sheet No. 1 of 2
PROJECT DEEP COAL CLEANING PILOT PLANT
DIV. No. 15
BY GWL
AREA PILOT PLANT
SUBJECT PUMP DATA SHEET

| File No. | Area | Sect. | Spec |
|---|---|---|---|
| | | — | — |

EQUIP/TAG Nos ______
DATE DECEMBER 17, 1985
REF. DWG. No ______
REV. DATES MARCH 17, 1986

| EQUIPMENT NO. | 20.63.05 | 20.63.06 | 30.63.07 | 40.63.08 |
|---|---|---|---|---|
| **Flow Quantities** | | | | |
| Solids, 5/h | 2.0 | 1.5 | | |
| Liquids, $m^3$/h | 3.0 | 37.0 | | |
| Solids, S.G. (max.) | 1.4 | 1.5 | | |
| Slurry, $m^3$/h | 4.4 | 38.0 | | |
| Slurry, S.G. | 1.15 | 1.05 | | |
| Solid-Liquid Concentration %WT | 40% | 4% | | |
| Max. particle size, mm | 0.1 | 0.1 | | |
| Slurry factor | 1.1 | - | | |
| Froth factor | - | - | | |
| Design flow, $m^3$/h | 4.8 | 76 | | |
| **Pump Head** | | | | |
| Vertical lift, m | 7 | 10 | | |
| Friction loss, m | 0.6 | 0.4 | | |
| Nozzle discharge head, m | 1.0 | 37 | | |
| Total dynamic head, m | 8.6 | 47.4 | | |
| **Pump** | | | | |
| Size | ? | ? | | |
| R.P.M | ? | ? | | |
| Efficiency, % | ? | ? | | |
| **Motor** | | | | |
| Power required, kW | ? | ? | | |
| Motor installed, kW | ? | ? | | |

? To be completed by bidder.

KILBORN

## PERFORMANCE SPECIFICATION No.

CLIENT EMR - CANMET
PROJ. No. 7813
Sheet No. 2 of 2
PROJECT DEEP COAL CLEANING PILOT PLANT
DIV. No. 15
BY GWL
AREA PILOT PLANT
SUBJECT PUMP DATA SHEET
EQUIP/TAG Nos
REF. DWG. No.

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

DATE DECEMBER 17, 1985
REV. DATES MARCH 17, 1986

| EQUIPMENT NO. | 10.63.01 | 10.63.02 | 20.63.03 | 20.63.04 |
|---|---|---|---|---|
| Flow Quantities | | | | |
| Solids, t/h | 2.0 | 8.0 | 2.0 | 2.0 |
| Liquids, $m^3/h$ | 2.0 | 45 | 39 | 18 |
| Solids, S.G. (max.) | 1.4 | 1.4 | 1.4 | 1.4 |
| Slurry, $m^3/h$ | 3.4 | 50.7 | 40.4 | 19.4 |
| Solid-Liquid Concentration % WT | 50% | 15% | 5% | 10% |
| Max. particle size, mm | 2.0 | 0.2 | 0.1 | 0.1 |
| Slurry factor | 1.1 | 1.05 | - | - |
| Froth factor | - | - | - | - |
| Design flow, $m^3/h$ | 3.7 | 53.2 | 40.4 | 14.4 |
| Pump Head | | | | |
| Vertical lift, m | 2.0 | 6.0 | 6.0 | 10 |
| Friction loss, m + 20% | 1.1 | 0.5 | 0.5 | 1.9 |
| Nozzle discharge head, m | 1.0 | 27 | 37 | 1.0 |
| Total dynamic head, m | 4.1 | 33.5 | 43.5 | 12.9 |
| Pump | | | | |
| Size | ? | ? | ? | ? |
| R.P.M. | ? | ? | ? | ? |
| Efficiency, % | ? | ? | ? | ? |
| Motor | | | | |
| Power required, kW | ? | ? | ? | ? |
| Motor installed, kW | ? | ? | ? | ? |

? To be completed by bidder.

**KILBORN** **PERFORMANCE SPECIFICATION No.** 7813-15-08

**CLIENT** EMR - CANMET **PROJ. No.** 7813 **Sheet No.** 3 **of** 1
**PROJECT** DEEP COAL CLEANING PILOT PLANT **DIV. No.** 15 **BY** G.W. LAMAN
**AREA** PILOT PLANT
**SUBJECT** WET MAGNETIC DRUM SEPARATOR

| File No. | Area | Sect. | Spec. |
|---|---|---|---|
| | | — | — |

**EQUIP/TAG No.s**
**DATE** JANUARY 2, 1986
**REF. DWG. No.**
**REV. DATES** MARCH 17, 198

1.0 SCOPE OF WORK

This specification covers the design, fabrication, supply and delivery of one (1) wet magnetic drum separator complete with all necessary accessories and controls, herein referred to collectively as the equipment.

1.1 Service

The magnetic drum separator shall recover fine ferro-magnetic particles suspended in water. The feed to the equipment is coal cleaned in heavy media process and subsequently ground to 95% - 325 mesh in a closed circuit ball mill.

2.0 DESCRIPTION OF EQUIPMENT

The equipment shall be a single drum magnetic separator of the concurrent type.

The Vendor shall verify and indicate if the suggested size is in agreement with his selection.

The equipment supplied shall include the following features:

(a) Feed box with baffled weir;

(b) the trough shall be furnished with facilities for cleaning and inspection;

(c) the magnetics discharge chute shall have a minimum angle of 45°;

(d) the magnetic drum shall be fabricated from stainless steel containing a magnetic assembly with permanent ceramic magnets;

(e) all drive guards must be supplied and construction shall comply with OSHA standard and all the Federal and Provincial regulations applicable in Alberta.

## 3.0 DUTY

3.1 The equipment shall be of heavy duty design suitable for handling fine magnetic particles suspended in water in continuous pilot plant operation.

3.2 The equipment will be installed in a heated building.

## 4.0 OPERATING CONDITIONS

### Feed

Magnetics content (maximum) - 5% by weight

Slurry volume - 40.4 $m^3/h$

Solids by weight (now mag) - 5-15% by weight

### Discharge

Recovery of ferromagnetics - 99% by weight (minimum)

## 5.0 MATERIALS OF CONSTRUCTION

Materials of construction shall be manufacturer's standard for the duty specified.

## 6.0 PAINTING

Painting shall be manufacturer's standard for the duty specified.

## 7.0 ASSEMBLY

7.1 All components shall be assembled to the maximum extent possible prior to shipment. All assemblies shall be match marked and tagged.

7.2 Vendor shall supply any special tools required for installation and maintenance.

7.3 The equipment shall be clearly identified with a securely fastened stainless steel tag, listing equipment number, purchase order number, Vendor and relevant service data.

## 8.0 WORK BY OTHERS

8.1 Equipment installation.

8.2 Installation of external piping, chutes, etc.

8.3 Foundation and anchor bolt installation.

8.4 Installation of electrical motors, starter, external wiring, etc. (unless an integral part of the equipment).

## 9.0 ELECTRICAL REQUIREMENTS

All standard electric motors will be supplied by others. Vendor shall specify all necessary data for procurement. The Vendor shall size the motor and advise the horsepower, Rpm, frame size and starting torque requirement. The motor will be sent to the Vendor for mounting and for attaching the drive, if applicable.

## 10.0 VENDOR PROPOSAL INFORMATION

10.1 As per attached equipment information summary, which must be completed by the Bidder or the bid package will not be considered complete.

10.2 Proposal package shall include preliminary drawings indicating mounting arrangement complete with anchor bolt sizes and locations.

10.3 Vendor shall supply a spare parts list for one year of operation.

# KILBORN ENGINEERING (B. C.) LTD.

## PERFORMANCE SPECIFICATION NO. 7813-15-08

## MAGNETIC DISC SEPARATOR

## EQUIPMENT INFORMATION SUMMARY

Technical inforamtion to be supplied by the Bidder:

Equipment No.: ____________________

Bidder's Name: ____________________

Quotation Reference No.: ____________________

Manufacturer: ____________________

Point of Manufacturing: ____________________

Model No.: ____________________

Service: ____________________

Drum Diameter, mm: ____________________

Drum Length, mm: ____________________

Magnet Type and Rating: ____________________

| | | | |
|---|---|---|---|
| KILBORN | ENGINEERING STANDARD<br>For: PIPING SPECIFICATIONS | STD. 17-500-2 | |
| | | Proj.No. | Rev. |
| | | Div.No. 17 | A |
| | | Spec.No. | |
| ANSI. Rating | Max. Service Limit: PSIG. °F. | Corr'n. Allow. | |
| Application | | Pipe Spec. No. | |

## 1.0 EQUIPMENT NUMBERING

1.1 All Equipment Nos. will be according to the Project Equipment Ledger.

## 2.0 LINE NUMBERING SYSTEM

2.1 Line Number

100 - PSL - 151 - 01

01 — Sequential Line Number

151 — Piping Specification Number

PSL — Media Abbreviation

100 — Line Size (nominal S.I. size see Std. 17-500-8)

2.2 A line number shall run from one piece of equipment to another or to a logical ending, regardless of size or specification changes. In no case shall a line number change to two new numbers at a branch.

2.3 A line list shall be produced indicating the number origin and destination, size, spec, test and working temperature and pressure, insulation and tracing if any.

.1 Only lines which have the same media abbreviation shall appear on the same line list sheet.

| REV. | DATE | DESCRIPTION | Prep.By | APP'D |
|---|---|---|---|---|
| A | | ISSUED FOR CLIENT INFORMATION | | |
| | | | | |
| | | | | |
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KILBORN

## ENGINEERING STANDARD

For: PIPING SPECIFICATIONS

STD.
Proj.No. 7813
Div.No. 17
Spec.No.
Rev. A

ANSI Rating
Max. Service Limit: PSIG. °F
Corr'n. Allow.
Application
Pipe Spec. No.

For this Project, pipe sizes indicated on drawings and/or specifications will be nominal S.I. equivalents of I.P.S. nominal pipe sizes:

| Nominal I.P.S. Sizes<br>INCH | Nominal S.I. Sizes<br>MM |
|---|---|
| 1/4" | 6 |
| 3/8" | 10 |
| 1/2" | 15 |
| 3/4" | 20 |
| 1" | 25 |
| 1¼" | 32 |
| 1½" | 40 |
| 2" | 50 |
| 2½" | 65 |
| 3" | 80 |
| 4" | 100 |
| 5" | 125 |
| 6" | 150 |
| 8" | 200 |
| 10" | 250 |
| 12" | 300 |
| 14" | 350 |
| 16" | 400 |
| 18" | 450 |
| 20" | 500 |
| 24" | 600 |
| 30" | 750 |
| 36" | 900 |
| 48" | 1200 |

| REV. | DATE | DESCRIPTION | Prep.By | APP'D |
|---|---|---|---|---|
| A | FEB. 1986 | ISSUED FOR CLIENT INFORMATION | PC | |
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| | | | | |

FORM KE-S-17-S-1 REV 1

| | | |
|---|---|---|
| **KILBORN** | ENGINEERING STANDARD<br>PIPING SYMBOLS<br>For: SINGLE LINE PIPING<br>100 DIA AND SMALLER | STD. 17-301-3<br>Proj. No.<br>Div. No.<br>Spec. No. |
| | | R<br>A |

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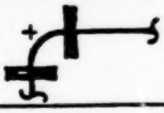
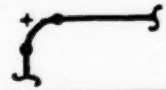
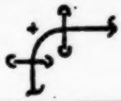
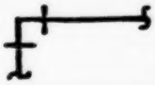
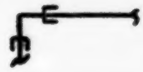
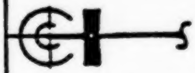
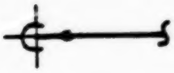
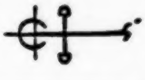
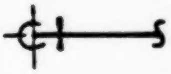
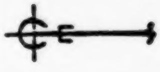
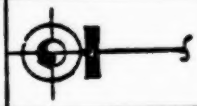
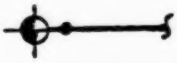
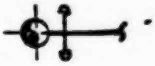
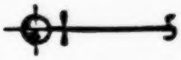
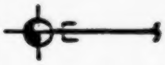
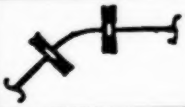
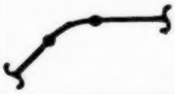
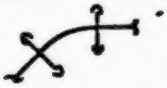
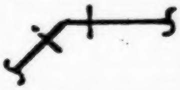
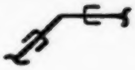
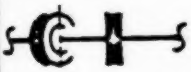
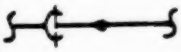
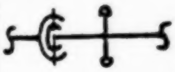
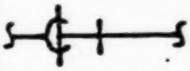
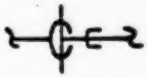
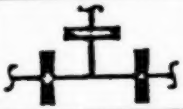
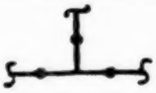
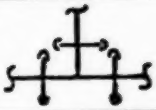
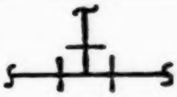
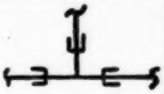
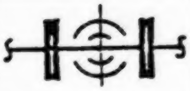
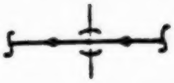
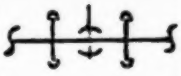
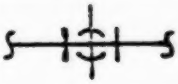
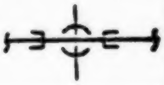
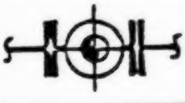
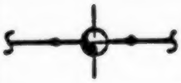
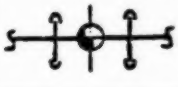
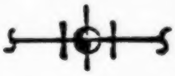
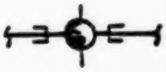
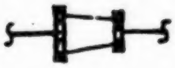
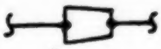
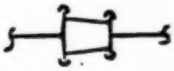
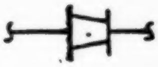
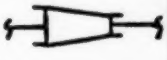
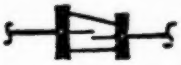
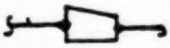
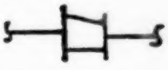
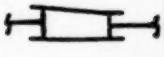
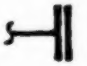
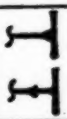
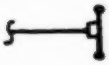
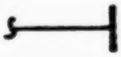
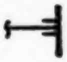
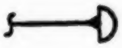
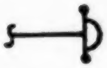
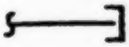
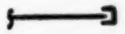
| 90° ELBOW |  |  |  |  |  |
| 90° ELBOW DOWN |  |  |  |  |  |
| 90° ELBOW UP |  |  |  |  |  |
| 45° ELBOW |  |  |  |  |  |
| 45° ELBOW DOWN |  |  |  |  |  |
| TEE |  |  |  |  |  |
| TEE DOWN |  |  |  |  |  |
| TEE UP |  |  |  |  |  |
| CONC. REDUCER |  |  |  |  |  |
| ECC. REDUCER |  |  | |  |  |
| FLANGE |  BLIND |  SLIP-ON<br>W/NECK |  |  |  |
| CAP | |  |  |  |  |

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FORM-KE 28, REV. I

KILBORN

## LINE APPLICATION CODE INDEX.

STD. 17-550-3

CLIENT SUPPLY & SERVICES CANADA

PROJ. No. 7813

PROJECT COAL DEEP CLEANING PILOT PLANT

DIV. No. 17

| CODE | SPEC. No. | APPLICATION | IDENTIFICATION | MAX. SERVICE LIMIT PRESS. PSIG. | MAX. SERVICE LIMIT TEMP. °F. | PIPE MATERIAL |
|---|---|---|---|---|---|---|
| PSL | 151 | Slurry | | | | C.S. |
| AP | 701 | Plant Air | | | | C.S. |
| AB | | Blower Air | | | | C.S. |
| VA | | Vacuum | | | | C.S. |
| WFR | 750 | Fresh Water | | | | C.S. |
| WPR | | Process Water | | | | C.S. |
| R | 562 | Reagents | | | | C.S. |

| REV. | DATE | DESCRIPTION | PREP. BY | APPR'D |
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|---|---|---|---|
| KILBORN | ENGINEERING STANDARD | STD. 17-550-3 | |
| | For: PIPING SPECIFICATIONS | Proj.No. 7813 | Rev. |
| | | Div.No. 25 | A |
| | | Spec.No. | |
| ANSI Rating | Max. Service Limit: PSIG. °F | Corr'n. Allow. | |
| Application | PSL | Pipe Spec.No. | 151 |

In this Specification, the name 'Victaulic' is used generally to denote grooved type fittings and couplings, approved equal items from alternative manufacturers are permitted.

| | |
|---|---|
| PIPE | |
| 40 thru 100 | Standard wall, carbon steel, ASTM A53 Grade A or B. (Plain ends.) |
| HOSE | |
| 40 thru 100 | 150 PSI working pressure, material conducting hose consisting of a 3 mm thick abrasion resistant tube, wrapped with heavy duck wire, reinforced and covered for indoor use (Goodrich converta-pipe, or approved equal). |
| FITTINGS | Bends |
| 40 thru 100 | Standard wall material, as per pipe 3 x nominal diameter radius bend with minimum 100 mm long tangents. (See Note 2.) |
| | Other Fittings |
| 40 thru 100 | Standard wall, forged carbon steel, ASTM A234, Grade WPB, 100 mm minimum straight welded to each end. (See Note 2.) |

| REV. | DATE | DESCRIPTION | Prep.By | APP'D |
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| | |
|---|---|
| FLANGES | |
| 40 thru 100 | 150 lb ANSI flat face forged carbon steel, ASTM A181, Grade 1 slip-on flanges. (See Note 3.) |
| COUPLINGS | |
| 40 thru 100 | Victaulic style 90 (Plainlock) mailleable iron ASTM A47 c/w flush seal Grade 'E' gasket. |
| GASKETS | 150 lb ANSI ring type 3 mm thick neoprene. |
| BOLTS | Hex Head machine bolts, carbon steel, ASTM A307, Grade B c/w heavy hex nuts. |
| VALVES | Stock Code No. |

| | Diaphragm | Knife Gate | Pinch |
|---|---|---|---|
| 40 thru 100 | IDM71 | 1KN65 | 1PH54 |

NOTES:

1. All knife gate valves to be supplied with ni-hard deflecting cones.
2. If 3X diameter bends cannot be used due to space limitations, long radius, standard wall carbon steel, ASTM A234, Grade WPB, elbows can be used.
3. Pipes and fittings connecting to equipment and valves, to have flanged ends.

| | | | |
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| KILBORN | **ENGINEERING STANDARD**<br>For: PIPING SPECIFICATIONS | STD.<br>Proj.No. 7813<br>Div.No. 15<br>Spec.No. | Rev. |
| ANSI Rating 150 | Max. Service Limit: 125 PSIG. 120 °F | Corr'n. Allow. | |
| Application | | Pipe Spec. No. | 561 |

| | |
|---|---|
| **PIPE** | |
| All sizes | Series 100 High Density Polyethylene Pipe (Spec. ASTM D1248) |
| **FITTINGS** | |
| 50 & below | Socket Fusion Fittings |
| 75 & above | Butt Fusion Fittings |
| **BENDS** | |
| All sizes | Sweep continuous runs of flexible pipe without kinking, or long sweep elbows |
| **FLANGES** | |
| All sizes | Stub ends on Polyethylene Pipe c/w Slip-on Metal Flanges (Spec. ASTM A181) |
| **THREADED ADAPTORS** | |
| 50 & below | Compression/Seal Fittings (NPT) c/w Stainless Steel Inserts Stiffeners |
| **GASKETS** | Full Face 1.5 mm thick Compressed Asbestos |
| **BOLTS** | Hex. Head Machine Bolts, Carbon Steel, ASTM A307, Grade 'B' c/w Heavy Hex. Nuts |
| **VALVES** | |
| 50 & below | Ball<br>2 BA1 |
| 95 & above | Ball<br>2 BA2 |

| REV. | DATE | DESCRIPTION | Prep.By | APP'D |
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| KILBORN | ENGINEERING STANDARD<br>FOR COAL DEEP CLEANING PILOT PLANT | STD. 17-550-3<br>PROJ. No. 7813<br>DIV. No. 17<br>SPEC. No. | REV.<br>A |

## PIPING SPECIFICATION NOS. 701 AND 750

NOTE: As an alternative to steel pipe and fittings for Specification Nos. 701 and 750, plastic pipe and fittings (PVC or ABS) can be used.

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(TITLE) PAGE 1 OF 1

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| KILBORN | **ENGINEERING STANDARD**<br>For: PIPING SPECIFICATIONS | STD. 17-550-3<br>Proj.No. 7813<br>Div.No. 17<br>Spec.No. | Rev.<br>A |
| ANSI Rating 150 lb | Max. Service Limit: PSIG. °F | Corr'n. Allow. | |
| Application AP AB VA | | Pipe Spec. No. | 701 |

| | |
|---|---|
| **PIPE** | |
| 50 & smaller | Standard wall carbon steel, ASTM A53 continuous weld, threaded ends. |
| 65 thru 100 | Standard wall carbon steel, ASTM A53, Grade A or B ERW, bevelled ends. |
| **FITTINGS** | |
| 50 & smaller | 150 lb malleable iron ASTM A47, banded, screwed ends. |
| 65 thru 100 | Standard wall, forged carbon steel, ASTM A234, Grade WPB, bevelled ends. |
| **FLANGES** | |
| 50 & smaller | 150 lb ANSI, flat face forged carbon steel, ASTM A181, Grade 1, threaded. |
| 65 thru 100 | 150 lb ANSI, flat face forged carbon steel, ASTM A181, Grade 1 slip-on, standard bore. |
| **UNIONS** | |
| 50 & smaller | 150 lb malleable iron ASTM A47, screwed, bronze to iron seat. |
| **GASKETS** | 150 lb ANSI ring type 1.5 mm thick compressed asbestos. |

| REV. | DATE | DESCRIPTION | Prep.By | APP'D |
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|---|---|---|---|
| BOLTS | Hex Head machine bolts, carbon steel, ASTM A307, Grade B, c/w heavy hex nuts. | | |
| VAVLES | Stock Code No. | | |
| | Butterfly | Check | Diaphragm |
| 50 & smaller | | 2CH1 | 1DM1 |
| 65 thru 100 | 2BU98 | | |
| NOTES: | 1. Use Teflon threading tape for all screwed joints. | | |

FORM KE-3-17-8-2 REV O.

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|---|---|---|---|
| KILBORN | **ENGINEERING STANDARD**<br>For: PIPING SPECIFICATIONS | **STD.** 17-550-3 | |
| | | **Proj.No.** 7813 | **Rev.** |
| | | **Div.No.** 17 | A |
| | | **Spec.No.** | |
| **ANSI. Rating** 150 lb | **Max. Service Limit:** PSIG °F | **Corr'n. Allow.** | |
| **Application** | WFR WPR | **Pipe Spec. No.** | 750 |

The name 'Victaulic' is used in this Specification to generally denote grooved type fittings and couplings, approved equal items from alternative manufacturers are permitted.

| | |
|---|---|
| PIPE | |
| 50 & smaller | Standard wall carbon steel, ASTM A53, continuous weld, threaded ends. |
| 65 thru 100 | Standard wall carbon steel, ASTM A53 ERW Grade A or B, grooved ends. |
| FITTINGS | |
| 50 & smaller | 150 lb malleable iron, ASTM A47 banded screwed. |
| | Bends |
| 65 thru 100 | Victaulic style 100 and 110, malleable iron ASTM A47. |
| | Other Fittings |
| 65 thru 100 | Standard victaulic malleable iron, ASTM A47. |
| FLANGES | |
| 50 & smaller | 150 lb ANSI flat-face carbon steel, ASTM A181, Grade 1, screwed. |
| 65 thru 100 | 125 lb ANSI victaulic style 741, malleable iron, ASTM A47, Grade 'E' gasket. |

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FORM KE-S-17-5-1 REV 1

**UNIONS**

| | |
|---|---|
| 50 & smaller | 3000 lb forged carbon steel, ASTM A105, screwed, steel to steel ground joint. |

**COUPLINGS**

| | |
|---|---|
| 65 thru 100 | Victaulic style 77, malleable iron, ASTM A47, c/w Grade 'E' gasket. |

**GASKETS**

| | |
|---|---|
| 65 thru 100 | 150 lb ANSI ring type 1.5 mm thick compressed asbestos. |

**BOLTS** Hex Head machine bolts, carbon steel, ASTM A307, Grade B c/w heavy hex nuts.

**VALVES** Stock Code No.

| | Check | Butterfly | Diaphragm |
|---|---|---|---|
| 50 & smaller | 2CH1 | | 1DM1 |
| 65 thru 100 | | 2BU98 | |

**NOTES:**

1. Teflon threading tape to be used on all threaded joints.

| | | | |
|---|---|---|---|
| **KILBORN** | **ENGINEERING STANDARD**<br>FOR VALVE STOCK LIST | STD. 17-550-4 | |
| | | PROJ. No. 7813 | REV. |
| | | DIV. No. 17 | A |
| | | SPEC. No. | |

## VALVE CODING

| RATING | TYPE | PAGE NO. |
|---|---|---|
| 1. 125 lb and lower | DM | 1 |
| 2. 150 lb | CH | 2 |
| | KN | 3 |
| | PH | 4 |
| | BU | 5 |

## VALVE CODING EXAMPLE

2 CH 1

1 — Identification No.

CH — Check Valve

2 — 150 lb rating

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## VALVE STOCK CODE LIST

## 125 LB DIAPHRAGM VALVE

| | |
|---|---|
| 1DM1 | 125 lb screwed diaphragm valve, weir type, cast iron body, neoprene diaphragm non-indicating stem, handwheel operated.<br>Grinnel 2401-1-T or approved equal. |
| 1DM71 | 125 lb f.f. flanged diaphragm valve, straightway, cast iron body, natural rubber diaphragm indicating stem, handwheel operated. Grinnel 2811-2-55 or approved equal. |

## VALVE STOCK CODE LIST

## CHECK VALVE

| | |
|---|---|
| 2CH1 | 150 lb screwed check valve, bronze body and trim, Y-pattern horizontal or vertical, integral seat screwed cap.<br>Crane 137 or approved equal. |

## VALVE STOCK CODE LIST

## KNIFE GATE VALVES

| | |
|---|---|
| 1KN65 | 125 lb RF flanged bonnetless knife gate valve, wafer type, cast iron body, 304 SS wetted parts, teflon asbestos packing, 304 SS metal seat, handwheel operated, c/w two tappings in body at 5 and 7 o'clock, one either side of slides, for flushing and c/w ni-hard deflector cone.<br>Dezurik series C800-W-C-610-152-X or approved equal. |

## VALVE STOCK CODE LIST

## PINCH VALVES

| | |
|---|---|
| 1PH54 | 150 lb ANSI rubber pinch valve abrasion resistant sleeve (Linatex or equal) c/w cast iron or steel split flanged ends. Standard handwheel operated.<br>Jaco type ST or approved equal. |

## VALVE STOCK CODE LIST

## BUTTERFLY VALVE

| | |
|---|---|
| 2BU98<br>(50 mm-150 mm) | 150 lb Butterfly valve, wafer type, cast iron body, E.P.D.M. or BUNA-N seat, aluminum bronze disc, 304SS or 316SS shaft shaft, c/w lever actuator.<br>Keystone F1000-CLJ2 c/w F401 lever or approved equal. |

# APPENDIX 'D'

# VENDOR CORRESPONDENCE

SMW 264 ATTN: MR. R. J. DAVIES

SUBJECT: SRR BALL MILL FOR CLR OF CANMET, EDM.
YOUR REF.: PROJ. NO. 7813
OUR TLX BUDGET QUOTATION NO. 85/3724

FURTHER TO YOUR ABOVE REFERENCED INQUIRY WE ARE PLEASED TO QUOTE THE BELOW LISTED OPTIONS BASED ON THE FOLLOWING CONDITIONS AND ASSUMPTIONS:

- DUE TO THE NATURE OF THIS PILOT PLANT HAVING TO TREAT COALS VARYING FROM SUB-BITUMINOUS TO ANTHRACITE, HAVE SELECTED WI (BOND) = 15 AND BASED ALL CALC. ON SAME.
- ALL SIZING BASED STRICTLY ON PAST EXPERIENCE AND CALC. ONLY.

- ASSUMING WET GRINDING IN CLOSE CIRCUIT (BY CUST.)

- CASE 1) FEED 80 PERCENT MINUS 300 MICRON

  A) PROD. 80 PERCENT MINUS 45 MICRON
  B) PROD. 80 PERCENT MINUS 22 MICRON

- CASE 2) FEED 80 PERCENT MINUS 1200 MICRON

  A) PROD. 80 PERCENT - 45 MICRON
  B) PROD. 80 PERCENT - 22 MICRON

CASE 1-A

ONE (1) ONLY SALA SRR OVERFLOW BALL MILL, 1500 MM DIA X 2400 MM LONG (5' X 8' NOMINAL).... 119,200.00 DLRS

APPROX. WT.... 8.500 KG
1-75 HP MOTOR REQ'D

CASE 1-B

ONE (1) ONLY SALA SRR O/F BALL MILL, 1800 MM DIA X 3000 MM LONG (6' X 10' NOM.).....146,000.00 DLRS

APPROX. WT....17.800 KG
1-150 HP DRIVE MOTOR REQ'D

CASE 2-A

ONE (1) ONLY SALA TYPE SRR O/F BALL MILL, 1500 MM DIA X 3000 MM LONG (5' X 10' NOM.)

.....131,200.00 DLRS
APPROX WT....10,600 KG.
1-100 HP MOTOR REQ'D.

CASE 2-B

ONE (1) ONLY SALA TYPE SRR O/F BALL MILL. 1800 MM DIA X 3600 MM LONG (6' X 12' NOMINAL)
.....158,900.00 DLRS
APPROX. WT.....19,800 KG.
1-200 HP DRIVE MOTOR REQ'D

- ABOVE PRICES CDN DLRS., F.O.B. SALA MISSISSAUGA, ONTARIO. ALL TAXES EXTRA, STD SALA TERMS AND SALES COND. TO APPLY.

- QUOTED DRIVE MOTORS ARE 1800 RPM, TO BE SUPPLIED BY CUST.

- STATED WEIGHTS ARE EXCLUSIVE OF BALL CHARGE

- ABOVE QUOTED MILLS ARE PRINCIPALLY AS PER LEAFLET 7850 GB INCLUDING REPLACEABLE RUBBER LINERS AND LIFTERS, MOUNTING FRAME, DISCH. TROMMEL AND FEED SPOUT, DRIVE AND GUARDS BUT EXCLUDING FOUNDATION BOLTS, GRINDING CHARGE AND DRIVE MOTOR. SRR MILL IS SUPPLIED AS A FULLY OPERATIONAL UNIT, FACTORY ASSEMBLED AND TESTED PRIOR TO SHIPMENT.

BEST REGADS
MILOS POSPISIL
SB
*
KILBORNENG VCR

SALAMACH CKVL

SMW 370

ATTN: MR. [redacted]

F    YOUR MSG NO. 0149 JAN. 13/86
     COAL GRINDING SYSTEM FOR EDMONTON
     COAL RESEARCH LAB. (CRL)

FOR THE SPECIFIED DUTY AND THE ASSUMPTION THAT THE BOND INDEX IS WI=15 WE RECOMMEND THE SRR 1800 X 3600 AS PER OUR TELEX QUOTATION 85/3724 OF DEC. 18/85.

A SHORTER MILL TYPE SRR 1800 X 3000 COULD POSSIBLY BE SUFFICIENT, HOWEVER THE BOND FORMULA IS KNOWN TO BE LESS ACCURATE FOR VERY FINE GRINDING AS IN THIS CASE AND THEREFORE SOME ADDITIONAL SAFETY MARGIN WOULD BE REQUIRED.

EXTENSIVE LAB. TESTS DONE BY SALA HAVE CONFIRMED THE RELATIONSHIP BETWEEN HARDGROVE AND BOND AND AS MOST COALS SEEM TO BE IN THE HARDGROVE RANGE OF 40-55 THE ASSUMED WORK INDEX OF WI=15 SEEMS TO BE CORRECT.

WE DO NOT FEEL THAT A WORK INDEX TEST ON ONE SAMPLE WOULD BE JUSTIFIED AS A PILOT PLANT MILL WOULD HANDLE MANY TYPES OF COALS WITH DIFFERENT HARDNESS.

REGARDS
B.HAGELSTAM FOR MILOS POSPISIL
SALA MACHINE WORKS LTD.
[illegible]-961182
SB
*
KILBORNENG VCR

SALAMACH CKVL
M
*
KILBORNENG VCR

KILBORNLTD TOR

NR 00191    860115  1445

**ALLIS-CHALMERS**

247 THIRD STREET • CAMBRIDGE, MASSACHUSETTS 02142
617/868-2550 TELEX: 92-1475

SALA MAGNETICS OPERATION

ALLIS-CHALMERS ENERGY AND MINERALS
SYSTEMS COMPANY

RECEIVED
FEB 27 198
Ans'd

2.18.1986

Mr. Dave Osborne
Senior coal prep. eng.
Kilborne Eng. Ltd
1380 Burrard Str.
Vancouver, B.C. V6Z 2B7
Canada

Dear Mr. Osborne,

Following our telephone discussion of today, I am enclosing for your information

- copy of a memorandum , including a comparison between WHIMS and HGMS
- Bulletin SMI SM79-0001.

As you will note from the Bulletin, our units can be used for both wet and dry processing.
I hope you will find them of sufficient interest, and as discussed,you will include one of our units in your project.
The unit to be used in this project is carousel model 120-20.
If you have any questions please call me.

Sincerely yours,

Ionel Wechsler

ALLIS-CHALMERS CORPORATION

SALAMACH CKVL

NR 00022 860206 1105

ATTN: [redacted]

SMW 490

RE: SALA MAGNETIC SEPARATOR FOR COAL RESEARCH LAB,
OUR TELEX SMW 386 OF JAN. 17TH, 1986.

REFERRING TO A CONVERSATION WITH MR. PETER COSGROVE REGARDING AN INCREASE IN FEED CAPACITY TO 40 M3/H WE ARE PLEASED TO CONFIRM THE SELECTION OF A WS 906 DM SEPARATOR (DIA 916 X 600 MM) FOR THIS DUTY.

PRICE CDN DLRS 33,400.00

REGARDS
BJORN HAGELSTAM
SALA MACHINE WORKS LTD.
TLX 06-961182
SB
*
KILBORNENG VCR

SALAMACH CKVL
T

*
KILBORNENG VCR

KILBORNLTD TOR

*
KILBORNENG VCR

SALAMACH CKVL

NR 00017 860205 1628

ATTN: [redacted] - P. ENG. PROJECT MGR.

SMW 486

RE: FLOTATION CELLS FOR CANMET
EDMONTON COAL RESEARCH LAB. PILOT PLANT
SALA QUOTATION 86/3729

PLEASE BE ADVISED THAT WE HAVE REVISED THE PRICING FOR THE FLOTATION CELLS BASED ON INCREASED CANADIAN CONTENT.

THE NEW PRICE FOR THE PRIMARY AND SECONDARY CIRCUITS AS PER ITEM ONE OF THE SUBJECT QUOTATION WILL BE CDN DLRS 43,000.00/ PER CIRCUIT.

PLEASE NOTE THAT THIS PRICE INCLUDES A BLOWER ASSEMBLY AT CDN DLRS 3,500.00 AND A FABRICATED SUPPORT FRAME AT CDN DLRS 2,500.00 PER CIRCUIT.

.... WOULD RECOMMEND ONE LARGER BLOWER, COMMON FOR THE TWO

CIRCUITS. PLEASE ADVISE IF YOU WISH US TO QUOTE ON THIS UNIT.

REGARDS
BJORN HAGELSTAM
SALA MACHINE WORKS LTD.
TLX 06-961182
SB

*
KILBORNENG VCR

SALAMACH CKVL
O

**Carpco, Inc.**

20 Haines Street / Jacksonville, Florida 32206 U.S.A.
Cable Address: CARPCO / Telex: 5-6367 / Telephone: (904) 353-3681

Ref: S85-124

January 6, 1986

Mr. Gerrard Laman
KILBORN ENGINEERING (B.C.) LTD.
1380 Burrard Street
Vancouver, B.C. V6Z 2B7
Canada

Dear Mr. Laman:

SUBJECT: EMR - CANMET
PILOT PLANT — DEEP CLEANING

This will confirm our telephone conversation of January 3 regarding your request for general arrangement drawings for the electrostatic and wet high-intensity magnetic separators previously quoted by Carpco. Two copies of general arrangement drawings for both separators are enclosed as requested.

A copy of our telex to David Osborne regarding the classifying cyclones is also enclosed for your information.

Thank you for your continuing interest.

Sincerely yours,

CARPCO, INC.

F. S. Knoll
President and
Technical Director

FSK/cp

Enclosures: Copy Carpco Telex Ref. 117
Dwg. 4-650 (2 copies)
Dwg. 4-703 (2 copies)

*Electrostatic, Magnetic and Gravity Separation Systems*

KILBORNENG VCR
*
KILBORNENG VCR
REF. 117  JACKSONVILLE, FLORIDA  USA  JANUARY 6, 1986
T[redacted]LBORN ENGINEERING
F OM: FRANK KNOLL - CARPCO, INC.

RE: HYDROCYCLONES FOR EMR-CANMET

GERRARD LAMAN ASKED THAT WE TELEX YOU TO CONFIRM THAT MOZLEY FIVE- AND TWO-INCH HYDROCYCLONES CAN DIRECTLY SUBSTITUTE FOR THE SIX- AND THREE-INCH UNITS SPECIFIED IN YOUR PROJECT NO. 7813.

WE CONFIRM OUR QUOTATION 6794 CONFORMS TO YOUR SPECIFICATION M-004 AND THAT THE MOZLEY UNITS RECOMMENDED WILL MAKE A SHARPER CUT POINT THAN THE LARGER UNITS.

BEST REGARDS,
CARPCO JAX
*
KILBORNENG VCR
.....

*

**Carpco, Inc.**

4120 Haines Street / Jacksonville, Florida 32206 U.S.A.
Cable Address: CARPCO / Telex: 5-6367 / Telephone: (904) 353-3681

Ref: S86-359

February 27, 1986

Mr. David Osborne
KILBORN ENGINEERING (B.C.) LIMITED
1380 Burrard Street
Vancouver, B.C. V6Z 2B7
Canada

RECEIVED
FEB 28 198
Ans'd.

Dear Dave:

Subject: EMR-CANMET PILOT PLANT -- DEEP CLEANING

Per our phone conversations, the following recommendations for electrostatic and high-intensity wet magnetic separation of fine coal are provided.

Electrostatic Separation

We understand that the electrostatic unit will be used as a research and development device to treat thermally dried coal fines. The objective is to remove pyrite and ash from large batches (0.5 - 5.0 tons), thus producing an upgraded dry pulverized fuel.

Our specific recommendations and specifications for electrostatic separation of coal are:

1) The separator should be operated in a non-oxidizing, ionizing atmosphere, i.e. $CO_2$ or CO, to prevent the combustion of coal fines.

2) To implement this system, it is recommended that the unit be modified to be relatively gas-tight and use rotary-vane valves to accept feed and discharge products of separation. We recommend that Kilborn engineer these modifications to the electrostatic unit.

3) Reducing the oxygen content can be accomplished with carbon dioxide gas. The enclosure should be monitored to maintain a minumum level of oxygen. A closed-circuit system for dust handling will minimize the accumulation of airborne dust while maintaining a noncombustible environment.

4) The electrostatic separator should be isolated in a "clean room" environment with feed transported to and from the separator room.. Kilborn's experience with sealable conveying systems should be used to minimize the coal dust problem. The size of the clean room might be 4 m x 4 m x 4 m (LxWxH).

5) General specifications for the recommended HTE(36)121-46 unit are:

Separator Cube: 1.2 m x 1.4 m x 3.1 m (LxWxH)
Separator Power: 1.5 kW

...2

Electrostatic Separation (cont'd.)

6) Safety Statement:

While it is recognized that electrostatic separation of combustible materials such as fine coal can be achieved with proper safety precautions, Carpco cannot accept liability for use of the electrostatic separator for combustible material such as fine coal. The above recommendation should serve only as a guide to those wishing to pursue safe operation with said feed material.

High-Intensity Wet Magnetic Separation (HIWMS)

A Boxmag-Rapid HIWMS unit is capable of treating -325 coal fines in conjunction with a low-intensity scalping step. Boxmag is now able to offer a new matrix with grid wires in the horizontal mode which assures particle contact with high-gradient areas and increases particle dwell time. This improvement allows the separation of fine paramagnetic particles into the sub -20 micron size range.

By virtue of the matrix configuration and new machine design the Boxmag-Rapid Model HIW1 will remove at least 75% of the pyrite that would be taken out by an HGMS-type unit. Additionally, the Boxmag-Rapid Model HIW1 is a proven industrial separator and is a continuous operating separator.

Price for the HIW1 is US$89,320.00, F.O.B. United Kingdom port. Delivery: 16 weeks. Capacity is 500 kg/hour at solids ranging from 5-40% washwater.

We hope that the above clarifications and information will help you in your engineering study for the CANMET deep-cleaning coal pilot plant. Please telephone if you have any questions.

Sincerely yours,

CARPCO, INC.

F. S. Knoll

F. S. Knoll
President

FSK/jh

Enclosures: Bulletin 8572: HTE Series Industrial Electrostatic Separators
Drawing No. 4-650: General Arrangement Drawing HTE(36)121-46
Boxmag-Rapid Brochure: Range of High-Intensity Wet Magnetic Separators
Drawing No. 4-706: Outline of HIW1 Boxmag-Rapid Separator

**Carpco, Inc.**

120 Haines Street / Jacksonville, Florida 32206 U.S.A.
Cable Address: CARPCO / Telex: 5-6367 / Telephone: (904) 353-3681

Ref: S85-1563

November 20, 1985

Mr. D. G. Osborne
KILBORN ENGINEERING (B.C.) LTD.
1380 Burrard Street
Vancouver, B.C. V6Z 2B7
Canada

Dear Dave:

This letter is to confirm our telephone conversation regarding the two subjects described below:

1) CANMET'S DEEP-CLEANING PILOT-PLANT CIRCUIT

Information on Boxmag-Rapid's wet high-intensity magnetic separator for paramagnetic material, including pyrite, is attached for your review. We recommend the pilot-plant model, HIWP. This unit would be rated at ~500 kg/hr on coal, subject to laboratory test confirmation. The budget price for this separator is approximately US$36,000.00, FOB Jacksonville, Florida.

Information on the electrostatic separation of coal is the subject of several papers by Advanced Energy Dynamics of Natick, Massachusetts. The references we have are as follows:

1) Rich, S.R., 1980, "Pilot Plant Program for the AED Advanced Coal Cleaning System," Phase II, Contract No. 80-69, State of Ohio Department of Energy, August.

2) Rich, S.R., 1981, "Process for Reducing the Sulfur Content in Coal," U.S. Patent No. 4,260,394, April.

These people are using a pilot-plant Carpco separator in their Massachusetts laboratory; and we would recommend a similar unit, but 2 stages, if electrostatic separaton were to be pursued in depth. Special considerations would include operation of the separator in a noncombustible environment, i.e. nitrogen, with continuous sweeping of the separator with inert gas, a dust collection system to prevent the build-up of conductive material on the electrodes and other parts of the separator. Our new units do have an electrode blow-down option plus a provision for air extraction, but the inert atmosphere would have to be dealt with by others. Special electrodes would not be a requirement, assuming that an inert atmosphere could be provided. Our Model HTE(36)121-46 priced at approximately US$40,000.00, FOB Jacksonville, Florida, is recommended. This unit would have a nominal capacity on coal of 500 lbs/hr, subject to laboratory confirmation.

...2

Brochures on Mozley high-performance hydrocyclones are also attached. We would recommend the 2-inch diameter Mozley units for the fine cut size you described.

2) METHODS FOR EVALUATING MAGNETITE

Literature on the Magnachute manufactured by Boxmag-Rapid is enclosed. This is a good plant method (as you pointed out), as it is practical apparatus and not easily damaged. Current unit price is approximately US$550.00, FOB Jacksonville, Florida.

Boxmag also offers the Davis Tube; but, as we discussed, this is not up-to-date technology.

A magnetic susceptibility meter such as the Model 3101 manufactured by Bison Instruments of Minneapolis, Minnesota, offers considerable promise for high iron material such as magnetite. I see no reason why a set of standards could not be used in conjunction with this type of device to provide quick, accurate magnetic determinations.

Best regards.

Sincerely yours,

CARPCO, INC.

F. S. Knoll
President

FSK/cp

Enclosures: Boxmag-Rapid Brochures BR36 & BR28
Mozley H/C Asemblies Brochure
Mozley Test Rig Brochure
Mozley 2" H/C Flyer

TELEDYNE
READCO
901 SOUTH RICHLAND AVENUE
P. O. BOX 582
YORK, PENNSYLVANIA 17405
(717) 848-2801 TELEX: 84-0439

March 10, 1986

Kilborne Engineering Company
1380 Burrard Street
Vancouver, BC
Canada V6Z 2B7

RECEIVED
MAR 18 198
Ans'd.

Attention: Mr. D. G. Osborne

Dear Mr. Osborne:

Subject: Canmet Coal Pilot Plant
Pelletizing of Ultrafine Coal

We confirm our telephone conversation and exchange of telexes concerning the above subject. The application calls for the use of a 6' diameter disc pelletizer for the agglomeration of two metric tons per hour of ultrafine coal for the Canmet Coal pilot plant operation. The coal feed consists of 95% minus 325 mesh material and is to be converted into granular pellets at a moisture content ranging between 15 and 25 percent by weight.

We confirm our selection of a 6' disc for this application and quote as follows:

ONE (1) TR6 Teledyne Readco Disc Pelletizer with 6' diameter inclined pan, adjustable pan angle, with stationary but adjustable vane plows, spray system, 5 horsepower variable speed gearmotor, and pellet discharge chute. A dusthood will not be required in this case since the feed is moist and we assume, therefore, not dusty.

The liquid additive could be water sprayed into the pelletizer to form the pellets or it could be water and a binder additive of your choice. If a dry binder in powder form is used, such as starch, for example, this can be premixed into the coal feed prior to pelletizing.

Price of TR6 Disc Pelletizer ... $17,750.00 (U.S. dollars) F.O.B. York, PA. This price is firm, subject to acceptance within 60 days from date of proposal.

Our delivery is approximately eight to ten weeks after receipt of purchase order.

We enclose our composite Drawing CS-647 showing disc pelletizer sizes and also Drawing 188576 showing a 6' disc. This is a 6' disc as recently built for pelletizing of fine carbon dust.

As far as a pelletizing system is concerned, we usually recommend that a reliable and uniform controlled feeder is used, which can either be a screw feeder for relatively dry materials or a volumetric or gravimetric belt feeder for moist feed materials. Usually these feeders have an accuracy of plus or minus 2% volumetric and plus or minus 0.5% to 1% for gravimetric design. It is possible to tie in the water additive spray system to the solids feed rate and, therefore, insure a constant solids to spray ratio. The feeder should be located above the pelletizing disc, coming either from the front or the back of the pan, from a conveying source or a surge hopper into the pan. This allows for a vertical flexible feed chute to be used, which can be located at the exact feed point during startup. Small adjustments in the feed location and the location of the spray nozzles are very helpful during startup. Once fixed for the operation, these variables will remain constant to produce a certain pellet size.

Pellets should discharge freely from the pan through the discharge chute attached to the pelletizer and onto a belt conveyor which handles the pellets to the next point of process, such as a dryer. There should not be any surge storage or hopper hold-up for moist pellets.

We thank you for your inquiry and look forward to working with you on your application.

Yours truly,

TELEDYNE READCO

Wm. H. Engelleitner
Wm. H. Engelleitner
Manager - Agglomeration

WHE/km
Enclosures

# TELEDYNE READCO CAPABILITIES

Teledyne Readco is part of Teledyne, Inc. represented worldwide by a great diversity of products and technologies from machinery and metals for industry, circuitry for aviation and space exploration, engines, energy and power to commercial and consumer products. Teledyne Readco is a leading manufacturer of chemical and food processing mixing equipment, serving industry for over 75 years. It is only natural that we provide agglomeration capabilities to expand our range of bulk solids and powder processing services.

## EQUIPMENT MANUFACTURING

- **I. Agglomeration**
  - Disc Pelletizers
  - Pugmills - Paddle Mixers
  - Continuous Ribbon Blenders and Conditioners
  - Processing Conveyors and Flakers
- **II. Mixing**
  - Continuous Processor
  - Batch Mixers
  - Dual Level Mixers
  - Batch Ribbon Blenders

## LABORATORY FACILITIES

Teledyne Readco's laboratory research teams conduct tests from small five gallon samples to tonnage quantities. Qualified engineers and technicians are available to work out processing problems, determine production rates and choose proper equipment for the job. Available laboratory equipment includes batch and continuous mixers, volumetric and gravimetric feeders, facilities for heating and cooling from 0° to 600°F, for handling viscous materials and for preparation of binder mixtures. Also available are pugmills, pelletizers, belt cooler-flakers, dryers and the necessary physical strength testing equipment.

## PILOT PLANT AND TONNAGE TESTING

Equipment can be set up in pilot plant arrangements and for continuous testing of larger material tonnages for semiworks evaluations and tolling.

## RENTAL EQUIPMENT

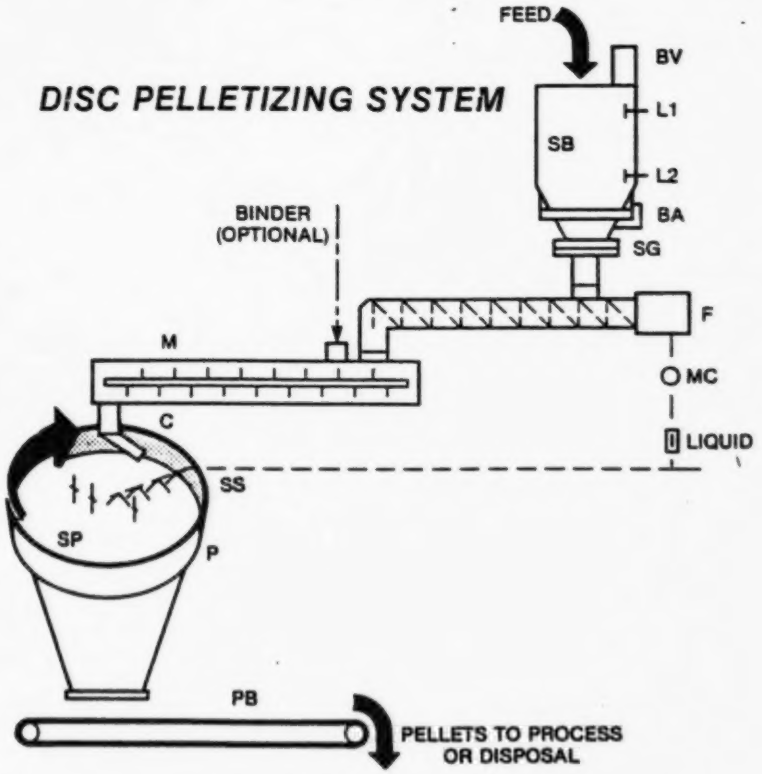
Small to medium sized agglomeration equipment is available on a rental basis, for short and long term lease. This includes support equipment such as feeders, mixers, dryers, and screens.

## ENGINEERING AND PROCESS SYSTEMS

Preliminary process engineering and design engineering of complete systems for bulk solids mixing and agglomerating can be provided. A typical pelletizing system and its process is shown below. This includes storage, proportioning, feed control, pelletizing and material handling. Secondary processing such as drying or curing may also be involved.

## CONSULTING SERVICES

Agglomeration specialists can provide consulting services and process know-how for problem solving based on many years of practical experience in the field.



DISC PELLETIZING SYSTEM

| | | | |
|---|---|---|---|
| SB | SURGE STORAGE SILO | M | MIXER (OPTIONAL) |
| BV | BIN VENT | C | FEED CHUTE |
| L1 | HIGH LEVEL INDICATOR | P | PELLETIZER |
| L2 | LOW LEVEL INDICATOR | SS | SPRAY SYSTEM |
| BA | BIN BOTTOM ACTIVATOR | MC | MOISTURE CONTROL |
| SG | SHUTOFF GATE | PB | PELLET BELT |
| F | FEEDER (SCREW, BELT, ETC.) | SP | SCRAPERS/PLOWS |

*
KILBORNENG VCR

BIRD MACH SKN

MAR 10/86
REF NO. 4746

ATTN: [redacted]
COPY OF TELEX TO DAVE OSBORNE PLEASE

RE CANMET EDMONTON RESEARCH LAB PROJECT - CONFIRMING MY TELEPHONE CALL BASED ON LAB TEST OF SAMPLE SUBMITTED - THE MODEL ML2500 (18 X 54) QUOTED JAN 28, 1986 IS SIZED CORRECTLY FOR 98 PERCENT PLUS RECOVERY, 60 PERCENT PLUS CAKE SOLIDS AT FEED RATES SPECIFIED IN INQUIRY, AT 1000 XG, 18 SECONDS RETENTION TIME.

I REALIZE TEST SAMPLE WAS COARSER THAN EXPECTED AND.WHAT WAS CALLED FOR IN THE INQUIRY. HOWEVER, THE MACHINE QUOTED CAN OPERATE AT OVER 2500 XG AND AT FEED RATE SPECIFIED WILL HAVE A RETENTION TIME OF 60 SECONDS, WHICH SHOULD COMPENSATE FOR FINER PARTICLE SIZE.

IF THERE ARE ANY OTHER QUESTIONS, PLEASE ADVISE

REGARDS,

B.J. CLARKE
*
KILBORNENG VCR

BIRD MACH SKN

**BIRD**

**BIRD MACHINE COMPANY of CANADA, LIMITED**
SASKATOON, Saskatchewan

March 24, 1986

Kilborn Engineering (B.C.) Ltd.
1380 Burrard Street
VANCOUVER, B.C.
V6Z 2B7

ATTENTION: Mr. D.G. Osborne, P. Eng.
Senior Coal Preparation Engineer

REFERENCE: Centrifuge for Edmonton Coal Research Pilot Plant

Dear Dave:

I have confirmed with our South Walpole Engineering Department that it is permissible to install the main drive motor above the machine. It should be mounted on a separate stand not connected to the centrifuge base. Instead of a slide base, a base would have to be designed that would jack the motor up to tighten the v-belts. We can assist with the design of this if it is decided to install the motor in this manner.

If there are any questions or additional information is required, please do not hesitate contacting us.

Yours very truly,

BIRD MACHINE COMPANY OF CANADA, LIMITED

B.J. Clarke,
Sales Engineer

BJC/sjj

cc: Mike Schill
Neil Policow

2600 Wentz Avenue
Saskatoon, Saskatchewan
S7K 2L1
Phone: (306) 931-0801
Telex: 074-2677

6600 Trans-Canada Highway
Pointe-Claire, Quebec
H9R 4S2
Phone: (514) 694-6721
Telex: 05-822754

P. O. Box 2303
Orillia, Ontario
L3V 6S2
Phone: (705) 325-9701

## APPENDIX 'E'

## REPORTS ON CENTRIFUGE TEST WORK

**LABORATORY DATA SHEET – PRELIMINARY TESTS** **TEST REPORT NO.** 5034

Customer Kilborn Engineering (BC) Ltd, Vancouver Date tested 12 Feb 1986

Material Quinsam Pulverised Coal Slurry - CANMET

Problem To thicken to facilitate preparation of a coal-water mixture

Reference Kilborn letter dated Jan 16th and Peacock letter dated 17th Jan 1986

Slurry: Viscosity — Sp. Gr. 1.0744 Temp °C 20.0 pH 7.0

Liquor: Viscosity 1.0 cp Sp. Gr. 1.000 Temp °C 20.0

Solids: Kg/cu m 1190 at 40.0 % Moisture

Colour solids Black Liquor Colourless

Condition solids: Flocced Dispersed ✓

Particle size: See Remarks Shape Irregular

% Solids: W/W Feed 30.0 Cake Effluent

% Ash (db) of coal as received 19.9%

| Sample Re const | | Temp. 17.0 °C | | | Sample | | Temp. | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time Secs** | **cc. cake** | **% vol. cake** | **cake cond. cc.** | **eff. cond.** | **Time Secs** | **cc cake** | **% vol. cake** | **cake cond.** | **eff. cond.** |
| 10 | No apparent separation | | | | | | | | |
| 30 | 4.2 | 42.0 | 3.5 | Cloudy | | | | | |
| 60 | 4.1 | 41.0 | 4.0 | Clearing | | | | | |
| 90 | 4.1 | 41.0 | 4.1 | Clearing | | | | | |
| 120 | 4.1 | 41.0 | 4.1 | Ess. Clear | | | | | |
| 180 | | | | | | | | | |
| 240 | | | | | | | | | |

**REMARKS:**

A 5.0 kg dry sample of Quinsam coal, which was said to have been milled to minus 400 mesh (38 microns), was submitted for evaluation. Despite its description it was clear the sample contained appreciable oversize solids.

In the Kilborn Performance Specification No M005 a mean size of 25 microns, with 5.0% solids in excess of 45 microns, was quoted.

According to a wet sieve analyses on the material, as received, 40.2% of the feed solids were greater than 45 microns. This was generally confirmed by a microscopic examination. A different interpretation of the particle size distribution, determined by a laser light diffraction techniques in a Malvern 3600E Analyser, is given on the enclosed print-out.

This equipment, by its method of measurement, tends to give a larger representation of size consist on this type of "elongated cubic" particles than sieving. The difference in this case, however, was more exaggerated than normal.

The material, as received, which was initially reluctant to wet out even with the aid of wetting agents and dispersants, was mixed with towns water to form a slurry at 30.0% W/W solids concentration.

When a quantity of the resultant slurry was spun in a test tube centrifuge, which developed a separating effect of 1000 gravities, the solids separated and compacted readily after an inauspicious start.

REMARKS (2)

Clarity of the supernatent was better than anticipated, and contrary to expectation it was not necessary to have to resort to the use of polyelectrolytes (see table on previous page).

It is not uncommon for feeds reconstituted from dry powders to be easier to separate them bona fide plant produced suspensions. As a consequence the ease of which a comparatively clear liquor was obtained in this investigation may have been connected with feed preparation.

Overlooking this possibility these test results indicate a solid bowl decanter centrifuge would discharge a cake as a semi-mobile sludge at 40.0% moisture whilst recovering in excess of 98.0% of the feed solids as cake.

for THOMAS BROADBENTS & SONS LIMITED

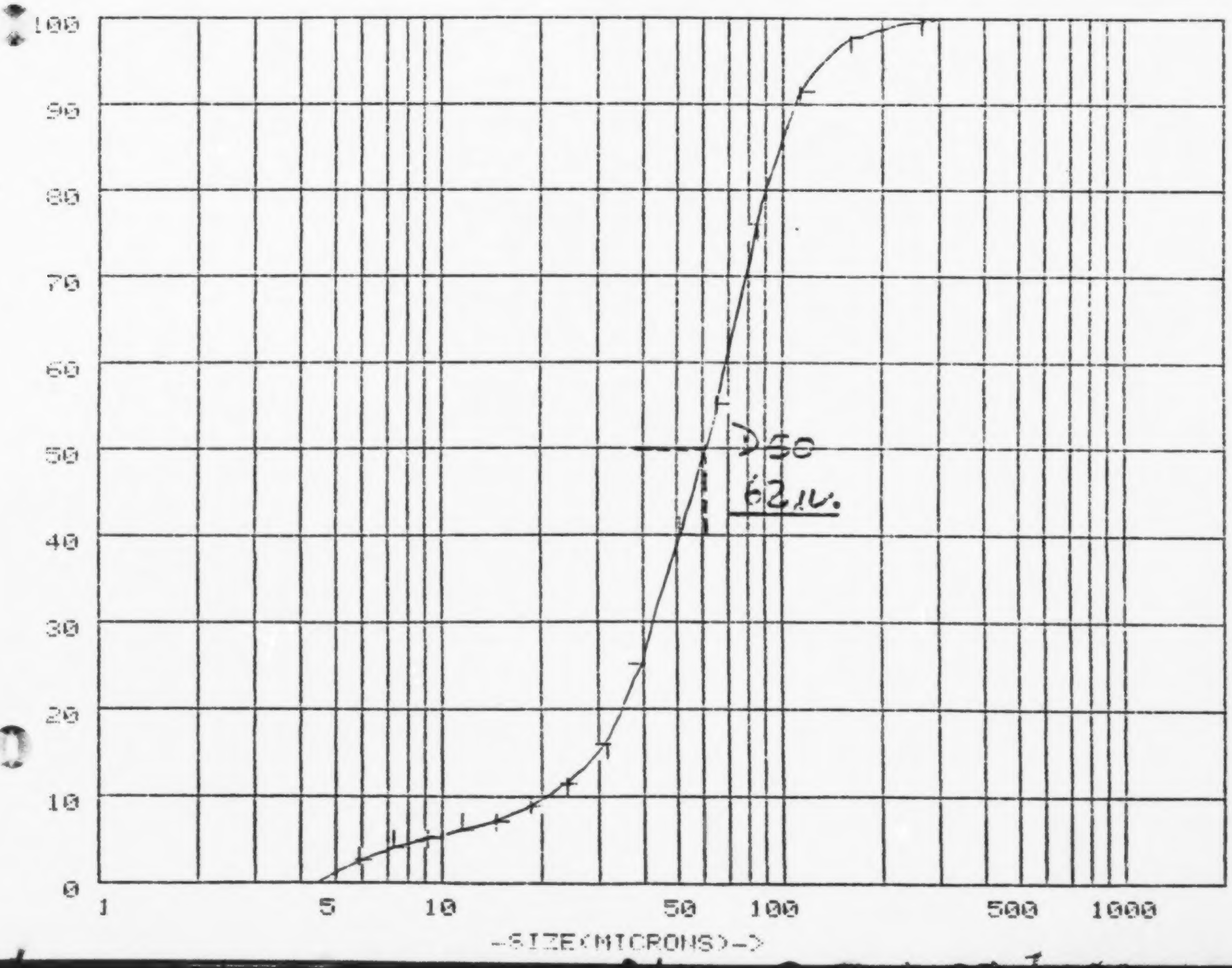
J R Thwaite.

J R Thwaite
Assistant Manager
Process Laboratory

Your comments on the discrepancy in the particle size distribution of the submitted sample and that quoted in the enquiry would be appreciated.

```
                    BROADBENT   CENTRIFUGES
BROADBENT HUDDERSFIELD.ENGLAND.   TELEX 51515  TEL 0484 22111
             MALVERN  3600 ETYPE PARTICLE SIZER VA.3

|USER EXPERIMENTAL AND SAMPLE DETAILS    Test Report No 5034
|KILBORN ENGINEERING BC LTD CANMET EDMONTON CRL
|QUINSAM PULVERISED RAW COAL
|FEED SOLIDS
|11 FEB 1986 JRT
| RESULTS
|RUN NUMBER= 2              TIME=08-46-20              LOG DIFFERENCE= 3.65 |
|SAMPLE % VOLUME CONCENTRATION= 0.0086             BEAM OBSCURATION= 0.11 |
|    SIZE       WEIGHT   |  WEIGHT  IN BAND              |     LIGHT ENERGY
|  MICRONS    % UNDER    |     MICRONS           %       | CALCULATED  MEASURED|
|   564.0       100.0    |                               |
|   261.6        99.8    |  564.0-   261.6       0.2     |    140         122
|   160.4        97.7    |  261.6-   160.4       2.2     |    241         234
|   112.8        91.3    |  160.4-   112.8       6.4     |    362         356
|    84.3        75.8    |  112.8-    84.3      15.5     |    508         503
|    64.6        55.2    |   84.3-    64.6      20.6     |    691         700
|    50.2        40.1    |   64.6-    50.2      15.1     |    872         857
|    39.0        25.1    |   50.2-    39.0      15.0     |   1034        1022
|    30.3        15.9    |   39.0-    30.3       9.2     |   1128        1153
|    23.7        11.4    |   30.3-    23.7       4.4     |   1345        1304
|    18.5         8.8    |   23.7-    18.5       2.7     |   1455        1442
|    14.5         7.2    |   18.5-    14.5       1.6     |   1554        1565
|    11.4         6.1    |   14.5-    11.4       1.1     |   1723        1719
|     9.1         5.2    |   11.4-     9.1       1.0     |   1845        1806
|     7.2         4.0    |    9.1-     7.2       1.1     |   1911        1921
|     5.8         2.7    |    7.2-     5.8       1.3     |   2047        2047
```



BIRD

**BIRD MACHINE COMPANY of CANADA, LIMITED**
SASKATOON, Saskatchewan

March 11, 1986

RECEIVED
MAR 1[illegible] [illegible]
Ans'd.

Kilborn Engineering (B.C.) Ltd.
1380 Burrard Street
VANCOUVER, B.C.
V6Z 2B7

ATTENTION: Mr. D.G. Osborne, P. Eng.
Senior Coal Preparation Engineer

REFERENCE: Centrifuge for Edmonton Coal Research Pilot Plant
Preliminary Laboratory Test Report Number 11003

Dear Dave:

I have attached a copy of the Laboratory Report 11003. You may have already received one directly from South Walpole.

The sample received was coarser than we had expected. It was essentially all minus 100 mesh with average size of 270 mesh (150 microns/53 microns). The inquiry called for 95% -325 mesh, 50% -400 mesh.

I understand there was some question about the size of the centrifuge we offered and I have attached a copy of the telex I sent to Jim Davies. Neil Policow reviewed the Lab report and confirmed the sizing was good.

I hope this provides the information you require at this time. Please call if there are any questions or you need anything else.

Yours very truly,

BIRD MACHINE COMPANY OF CANADA, LIMITED

BJC

B.J. Clarke,
Sales Engineer

BJC/sjj
Attachments

2600 Wentz Avenue
Saskatoon, Saskatchewan
S7K 2L1
Phone: (306) 931-0801
Telex: 074-2677

6600 Trans-Canada Highway
Pointe-Claire, Quebec
H9R 4S2
Phone: (514) 694-6721
Telex: 05-822754

P. O. Box 2303
Orillia, Ontario
L3V 6S2
Phone: (705) 325-9701

04-507734ϕ

04-507734ϕ‡
KILBORNENG VCR
ϕ
BIRD MACH SKN

MAR 10/86
REF NO. 4746

ATTN: JIM DAVIES
COPY OF TELEX TO DAVE OSBORNE PLEASE

RE CANMET EDMONTON RESEARCH LAB PROJECT - CONFIRMING MY TELEPHONE CALL BASED ON LAB TEST OF SAMPLE SUBMITTED - THE MODEL ML2500 (18 X 54) QUOTED JAN 28, 1986 IS SIZED CORRECTLY FOR 98 PERCENT PLUS RECOVERY, 60 PERCENT PLUS CAKE SOLIDS AT FEED RATES SPECIFIED IN INQUIRY, AT 1000 XG, 18 SECONDS RETENTION TIME.

I REALIZE TEST SAMPLE WAS COARSER THAN EXPECTED AND WHAT WAS CALLED FOR IN THE INQUIRY. HOWEVER, THE MACHINE QUOTED CAN OPERATE AT OVER 2500 XG AND AT FEED RATE SPECIFIED WILL HAVE A RETENTION TIME OF 60 SECONDS, WHICH SHOULD COMPENSATE FOR FINER PARTICLE SIZE.

IF THERE ARE ANY OTHER QUESTIONS, PLEASE ADVISE

REGARDS,

B.J. CLARKE
‡
KILBORNENG VCR
ϕ
BIRD MACH SKN

B. Clarke

**Preliminary Laboratory Test**

**Report Number:** 11003

**Page** 1 **of** 6

**Customer:**

Kilborn Engineering Ltd.
1380 Burrard St.
Vancouver, BC Canada

**Product:** Fine Coal

**File:** 215540

**Material:**

Fine Coal

**Purpose/Application:**

Clarification & Dewatering

40%ss fine coal
18 gpm 4400 #/hr solids
maximum recovery
cake solids not important

**Summary:**

Essentially complete recovery obtainable at low gravitational level with 15-20 sec retention. Cake is 61% solids. If floc is added cake is 58% solids.

**Sample No.** 18 **Amount Received** 1 bag **Date Received** 1/24/86

**Analyst** MAM **Date Tested** 2/11/86 **Area Representative** B. Clarke

Sample Preparation:

Dry solids are received slurried in tap water.

## Feed Slurry As Tested

% suspended solids 39.8

Sp. Grav. 1.07 %Ash 7.52

Temp amb

Viscosity

## Mother Liquor

% dissolved solids 0.1

pH 7

Color Clear

Composition Water

Sp. Grav. 1.00

Temp amb

Viscosity

## Solids

Color Black

Shape amorphous

Size min 1 micron

max 150 microns

avg 53 microns

Other Characteristics Noted:

## SPIN TUBE TEST

The ability to centrifuge a sample can be readily determined with a test tube spinner. If material is applicable to centrifugation, it will spin down in a reasonable time at a given centrifugal force and compact into a bulky cake suitable for conveying. A 15 ml spin tube is used for this test. The tube is filled to the 10 ml mark and spun at a number of gravitational levels. Compaction is measured by placing a glass rod on the surface of the settled solids and measuring the point to which the rod penetrates.

| | SEC | cc CAKE | % VOL CAKE | CAKE COND | EFF COND |
|---|---|---|---|---|---|
| 500XG | 10 | 6.8 | 68 | 1.9 | Cloudy |
| | 30 | 7.0 | 70 | 2.0 | " |
| | 60 | 7.1 | 71 | 2.5 | " |
| | 90 | 6.8 | 68 | 3.0 | " |
| 750XG | 10 | 7.2 | 72 | 2.7 | Cloudy |
| | 30 | 7.0 | 70 | 4.0 | Slightly Cloudy |
| | 60 | 6.9 | 69 | 5.2 | Ess.Clear |
| | 90 | 6.8 | 68 | 5.3 | " " |
| 1000XG | 10 | 7.1 | 71 | 3.5 | Cloudy |
| | 30 | 6.8 | 68 | 5.0 | Ess.Clear |
| | 60 | 6.7 | 67 | 5.2 | " " |
| | 90 | 6.6 | 66 | 5.5 | " " |
| 2000XG | 10 | 7.6 | 76 | 3.5 | Cloudy |
| | 30 | 6.8 | 68 | 5.0 | Slightly Cloudy |
| | 60 | 6.7 | 67 | 5.2 | Ess.Clear |
| | 90 | 6.6 | 66 | 5.5 | " " |

Acceptable floculants for this material include:

| | |
|---|---|
| Hercules | 1018 |
| Allied Collords | 787 |
| Agna Ben | 686 |
| Calgon | K400 |
| American Cyanamid | 1563C |

## Spin Tube

Flocced sample (Hercules 1018)
750XG

| | SEC | cc CAKE | % VOL CAKE | CAKE COND | EFF COND |
|---|---|---|---|---|---|
| 0.31#/T | 10 | 7.0 | 70 | 5.5 | Clear |
| | 30 | 6.8 | 68 | 6 | " |
| | 60 | 6.6 | 66 | 6 | " |
| | 90 | 6.6 | 66 | 6 | " |
| 0.62#/T | 10 | 6.4 | 64 | 5.8 | Clear |
| | 30 | 6.2 | 62 | 5.8 | " |
| | 60 | 6.1 | 61 | 5.8 | " |
| | 90 | 6.1 | 61 | 5.8 | " |

Oil may also be used as a flocculant.

| | | | | | |
|---|---|---|---|---|---|
| 1cc/60cc Feed | 10 | 7.4 | 74 | 5 | Cloudy |
| | 30 | 7.0 | 70 | 5.5 | " |
| | 60 | 6.8 | 68 | 5.5 | Slightly Cloudy |

600 weight waste oil was used for the above test.

## PULP CENTRIFUGE TEST

A small basket-type centrifuge is used to simulate the performance of a solid bowl centrifuge. The feed slurry is processed at various retention times and at varying gravitational levels to measure the effects of spinning time on recovery at a number of gravitational levels. The cake collected is typically similar to that obtained from an actual continuous solid bowl centrifuge except that the cake may be slightly wetter than would be seen in production. With a perforated basket containing a cotton liner, the effect of spin time and gravitational level in obtaining maximum cake solids is measured. The cakes collected here usually are the driest which can be obtained in production. Also the centrate is not as clean as found in the solid bowl basket due to the losses through the cloth liner.

### Solid Bowl

| | | | | | |
|---|---|---|---|---|---|
| % Feed (Solids) | 39.8 | 39.8 | 39.8 | 39.8 | 39.8 |
| % Cake ( " ) | 61.7 | 60.8 | 61.1 | 61.4 | 61.4 |
| %Efflvent ( " ) | 4.18 | 0.826 | 0.534 | 2.61 | 0.582 |
| %Recovery | 96.0 | 99.3 | 99.5 | 97.6 | 99.5 |
| Retention Time sec | 6 | 17 | 27 | 6 | 15 |
| ForceXG | 1000 | 1000 | 1000 | 2000 | 2000 |

No FLOC

| | | |
|---|---|---|
| %Feed | 39.8 | 39.8 |
| %Cake | 58.4 | 58.4 |
| %Efflvent | 0.791 | 0.461 |
| %Recovery | 99.4 | 99.8 |
| Retention Time Sec | 17 | 17 |
| ForceXG | 1000 | 1000 |
| #/T Floc (1018) | 0.11 | 0.33 |

With Floc

MAM:djc
2/14/86

Typed: 2/19/86

LEEDS & NORTHRUP MICROTRAC
PARTICLE ANALYSIS

Sample: Feed

**Channel Upper Limits Cumulative Graph:** A cumulative graph, either % smaller than or % larger than is produced, and read like the relative volume graph (see below) except that the channels are identified by printing their upper limits (for % smaller than) or lower limits (for % larger than) in microns. (This corresponds to printout of cumulative data where percentage is printed to 0.1%). For any channel, the value printed is the percentage of total volume which is smaller (or larger) than particle size.

```
125 2
 88 10
 62 -24
 44 --39
 31 ----53
 22 -----65
 16 ------74
 11 -------81
7.8 -------88
5.5 --------91
3.9 --------95
2.8 --------98
1.9 ---------0
```

**Relative Volume Distribution:** Percentage of particles counted in each channel.

```
150 18
106 ----52
 75 -------89
 53 ---------0
 38 -------88
 27 ------78
 19 ----59
 13 ---46
9.4 --39
6.6 -24
4.7 -22
3.3 18
2.4 11
```

**Histogram Data**
(% between listed size
and next smaller size)

**Cumulative Data**
(% smaller or larger)

**Channel Upper Limits**
**Microns**

**Cumulative & Histogram Data** The total range span of the analizer is divided into fixed channels or spans. When printing data (% smaller than or % larger than) and histogram data (% of total volume represented by each span), the channel is identified by printing its upper and lower limit in microns with cumulative and histogram % in each channel values on the same line.

```
125   2.7   2.7
 88  10.7   8.0
 62  24.5  13.7
 44  39.9  15.3
 31  53.5  13.6
 22  65.6  12.1
 16  74.7   9.0
 11  81.9   7.1
7.8  88.0   6.1
5.5  91.8   3.8
3.9  95.3   3.5
2.8  98.2   2.8
1.9 100.0   1.7

                .360  CS
                43.2  MV
                90.9  PH
                33.9  PM
                6.46  PS
                .644  dV
```

**CS-** specific surface area
**MV-** mean diameter volume
**PH-** 90th percentile
**PM-** 50th percentile
**PS-** 10th percentile
**dV-** uncalibrated sample volume

**Summary Date** Particle size in microns % smaller than of the volume distribution.

**CS-units in $m^2/cm^3$**

# APPENDIX 'F'

# DETAILS OF NRC SPHERICAL AGGLOMERATION PROCESS

NRCC/CHEM
CNRC/CHIMIE

**FACSIMILE MESSAGE**

DATE: February 28, 1986

TO/A: [redacted]

FROM/DE: Dr. C.E. Capes

# FACS: (604) 669-0847

SUBJECT/SUJET:

Oil Agglomeration Circuit (Equipment)

# of pages:
nombre de pages: 5 (including this cover page)

If there is any problem receiving this message, please call Suzanne at (613) 993-2455 or (613) 993-0198.

MESSAGE:

As requested in your facsimile dated February 26, 1986.

SIGNATURE: C. Edward Capes

Canada Canada

FILE NO [illegible]

DATE Feb. 27/86

A TO Dave Osborn, Kilborn Engng.

The flowsheet used in our mobile plant is attached. The details of equipment, using the same order of questions in your facsimile, are as follows:

1. High speed in-line mixer.
   - variable speed for research applications
   - max speed ≈ 2500 rpm; lowest speed ≈ 600 rpm
   - 20 HP
   - materials as in rest of plant (corrosion problem?) impellers normally stainless steel
   - 60 US gal. size

These details should be verified with our licensee of this high shear mixer, Hayward-Gordon.

Contact person: Andy B Pinch
Manager, Rotequip Inc.
315 Dorval Ave, #103
Dorval, Quebec
H9S 3H6
(514) 631-4301
telex 05-821 813.

Please note that Andy Pinch has worked with us for many years on the development of this mixer and is the person to contact in the first instance. He is now the owner of his own company which is an agent for Hayward Gordon. He is the only knowledgeable person about our agglomeration process in the company.

Conseil national de recherches Canada
National Research Council Canada

[illegible]

DOSSIER N°
FILE NO
DATE Feb. 27/86

À
TO Dave Osborn, Kilborn Engng

5. These sizings have plenty of safety factor (probably x2) for 2 tph capacity even at 10% solids feed. We normally use ≈ 20% solids.

6. Note that the skimmer arrangement shown in your drawing is out-of-date.

7. We also recommend that you make provision to bypass our final screens and send the agglomerated slurry back to your float cells. Two minutes floating (often much less) would be used for very small floc-agglomerates which might be made with very low oil levels and/or weakly-agglomerating coals. These would not normally be recovered on screens but in a float cell.

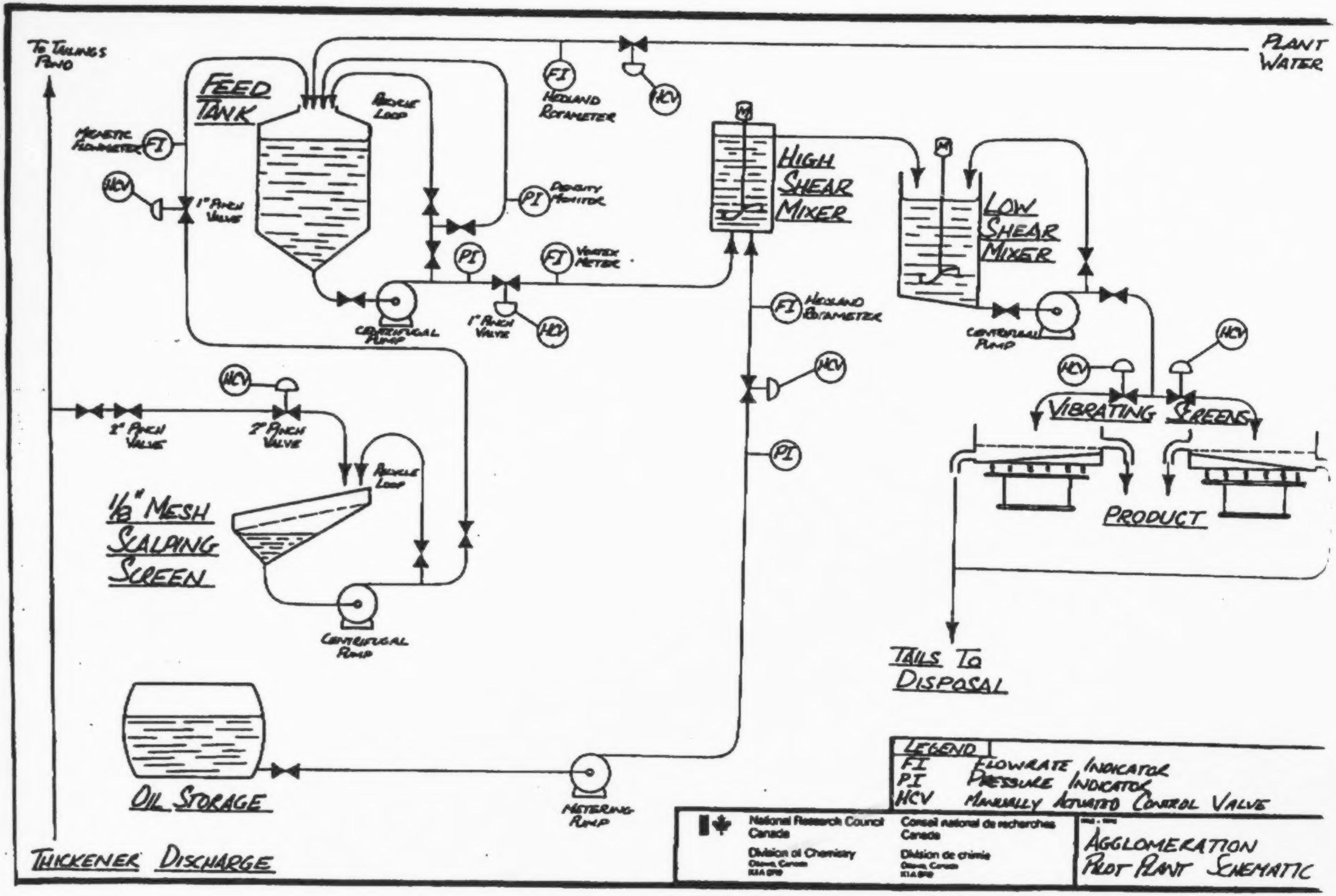
8. For pelletizing, I suggest a 6 ft. diameter disc, 5HP driv
Source of information on this is ← Bill Engelleitner
Manager, Agglomeration Equipment
Teledyne Readco
901 South Richland Ave.
PO Box 552, York, PA 17405
(412) 264-0619

Note that, depending on the extent of dewatering of the feed to
the disc, water may accumulate on the disc. Provision to centrifuge
the feed may be necessary. Also just heating the oil binder
may not lead to very regular larger pellets due to large
mass of cold incoming feed. But, a coarse granular product
would still be produced on disc.

9. Let me know if you have questions.

Ed Capes.

47 (1-8-71)



TO TAILINGS POND
PLANT WATER
FEED TANK
RECYCLE LOOP
MAGNETIC FLOWMETER
FI
HCV
1" PINCH VALVE
PI
DENSITY MONITOR
FI
HEDLAND ROTAMETER
FI
VORTEX METER
CENTRIFUGAL PUMP
1" PINCH VALVE
HIGH SHEAR MIXER
M
LOW SHEAR MIXER
CENTRIFUGAL PUMP
FI
HEDLAND ROTAMETER
HCV
PI
VIBRATING SCREENS
PRODUCT
TAILS TO DISPOSAL
2" PINCH VALVE
2" PINCH VALVE
RECYCLE LOOP
1/8" MESH SCALPING SCREEN
CENTRIFUGAL PUMP
OIL STORAGE
METERING PUMP
THICKENER DISCHARGE
LEGEND
FI FLOWRATE INDICATOR
PI PRESSURE INDICATOR
HCV MANUALLY ACTUATED CONTROL VALVE
National Research Council Canada
Division of Chemistry
Ottawa, Canada K1A 0R6
Conseil national de recherches Canada
Division de chimie
Ottawa, Canada K1A 0R6
AGGLOMERATION PILOT PLANT SCHEMATIC

Figur_ 2.

Conseil national de recherches Canada
National Research Council Canada

DOSSIER N°
FILE NO

DATE Feb 27/86

À
TO Dave Osborn, Kilborn Engng.

## 2. Low Speed Mixers

- fixed speed OK; we have variable speeds ourselves but think they are not really necessary
- suggest 500 gal tanks with matching mixers, probably 7½ HP each
- contact Andy Pinck for complete details. He can supply quote, if necessary.

## 3. Screen

We recommend a vibrating sieve bend for the permanent installation; but feel that provision for horizontal vibrating screens (eg Sweco type) should also be made for flexibility.

- Heyl & Paterson (4 ft wide × 5' long)
  profile wire screens
  100 mesh
- Sweco screens (Toronto supplier)
  suggest 2 machines of 30 inch diameter
  or 1 machine of 48 inch diameter
  100 mesh stainless steel screen

4. Regarding pumps, the only one needed on our mobile set-ups is the recirculating / delivery pump on the final low shear tank. We use Worthington slurry pumps, but have noted that the coal industry we deal with seems to like Warman pumps. And, I am sure you also have preferences. We will leave this choice to you.